PERFORMANCE ASSESSMENT OF DESIGN-BID-BUILD (D-B-B) VERSUS DESIGN-BUILD (D-B) IN TERMS OF TIME AND COST FOR CONSTRUCTION PROJECT INDUSTRIES IN SAUDI ARABIA.

BY

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DEDICATED TO
MY BELOVED PARENTS
AND ALL FAMILY MEMBERS

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I would like to acknowledge firstly my parents, who supported me with love. Without you, I could never have reached this current level of success.

Secondly, for everyone who played a role in my academic accomplishments. Thank you all for your unweaving support.

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LIST OF ABBREVIATIONS

DB	:	Design-Build
DBB	:	Design-Bid-Build
SPSS	:	Statistical Package for the Social Sciences
XLSTAT	:	Excel Statistics

ABSTRACT

Full Name : Raddad Abdullah Mohammed Musleh

Thesis Title : Performance Assessment of Design-Bid-Build (D-B-B) versus Design-Build (D-B) in terms of Time and Cost for Construction Project Industries in Saudi Arabia.

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Construction industry has developed in fast track and become the second important economic activity in Saudi Arabia after the oil industry. It's contribute into over than 11% of Saudi Arabia income and a round 28% of Saudi Arabia manpower working in the construction industry.

The delivery system in the construction industries in Saudi Arabia is one of the biggest factors that affect a project's performance negatively and approximately 70% are in Saudi Arabia Public Projects, due to the traditional delivery methods that are utilized in Saudi Arabia to select a contractor mostly depend on the lowest price.

In the DBB method, the contractors build the project according to the detailed design and specifications prepared by the engineers. But, in the DB method, the contractors are responsible for design and construction stage. Selecting project delivery system either DB or DBB, project performance has an impact on the time and cost.

In order to compare the performance of DB and DBB projects in terms of time and cost for construction project industries in Saudi Arabia, this study analyzed a sample of 44 DBB projects and 11 DB projects built in eastern region in Saudi Arabia. The sample includes projects completed between 2011 and 2018, cost more than 10 million Saudi riyals in design and construction value, and for different type of projects; residential, commercial, industrial, institutional buildings as well as infrastructure projects. Statistical tests by using **XLSTAT** software were conducted to determine if metrics related to schedule and cost were significantly different from each other in DB and DBB projects.

Besides comparing the total schedule and cost growth for design and construction stage for DB and DBB project the results showed that DB projects significantly outperformed DBB projects in terms of schedule saving for whole projects in general and especially for commercial projects. The study also found that DB residential projects significantly outperformed DBB projects in terms of cost per unit.

The general contribution of this study is to provide information to the owner's of construction projects in Saudi Arabia that the DB method has potential to reduce schedule, especially for commercial projects when selecting delivery method. In addition, the owner's of residential buildings has potential to reduce schedule as well as the cost per unit if they select B method.

The Second aim of this study is to understand the reason for not utilizing the DB delivery method in construction project industries in Saudi Arabia, due to the few samples of project data collection for the DB delivery method during the survey.

Close end survey established with 13 influencing factors to get a respond from the expert and practitioners of the construction industries in Saudi Arabia. The result of factors were analyzed and ranked by using **Statistical Package for the Social Sciences** (SPSS) software and found that the most important factors that influence the clients to not utilize the DB delivery method were respectively (1) Clarity of scope of work at an earlier time by the owner (2) Expectation of a high estimated cost by the contractor (3) Expected a lot of variations during the design and execution stage (4) Capabilities of the owner's team work. It’s recommended the owners of the projects that more clarity of scope of work at an earlier time with qualified team work and minimizes requesting a lot of changes in design and construction will guide to better selection of DB method.

ملخص الرسالة

الاسم الكامل: رداد عبدالله محمد مصلح

عنوان الرسالة: مقارنة أداء مشاريع التصميم والتنفيذ من قِبل مقاول واحد ومشاريع التصميم والمناقصة والتنفيذ من قِبل عدة أطراف للمشروع وذلك من حيث المدة الزمنية والتكلفة لمشاريع التشييد والبناء في المملكة العربية السعودية.

التخصص: هندسة وإدارة التشييد

تاريخ الدرجة العلمية: ديسمبر 2018م

تطورت أعمال البناء والتشييد في المملكة العربية السعودية بشكل متسارع حتى أصبحت ثاني أهم نشاط اقتصادي بعد انتاج النفط ، بحيث أصبحت أعمال البناء والتشييد تساهم في أكثر من 11٪ من دخل المملكة العربية السعودية و 28٪ من القوى العاملة في أعمال البناء والتشييد.

يعتبر نظام ترسية المشاريع للمقاولين في المملكة العربية السعودية أحد أكبر العوامل التي تؤثر على أداء المشروع بشكل سلبي ، حيث أن حوالي ما نسبته 70٪ من اجمالي المشاريع الحكومية في المملكة العربية السعودية كانت أداءها بشكل سلبي من ناحية التكلفة والمدة الزمنية وذلك نتيجة اتباع الطريقة التقليدية لترسية المقاولين والتي يتم اختيار المقاول في الغالب استناداً الى المقاول ذو الأقل سعراً.

بالنسبة لنظام ترسية المشاريع بالطريقة التقليدية (Design-Bid-Build) ، يقوم المقاولون ببناء المشروع وفقًا للمخططات والمواصفات التي يتم إعدادها مسبقاً من قبل المكتب الهندسي قبل البدء في التنفيذ . ولكن في نظام التصميم والتنفيذ في آن واحد (Design-Build) يعتبر المقاول هو

المسؤول عن مرحلة التصميم والتنفيذ ، بحيث يقوم المقاول بالبدء بمرحلة التنفيذ من وقت مبكر قبل الانتهاء من إعداد المخططات.

اختيارنظام ترسية المشاريع للمقاولين سواءً نظام (Design-Bid-Build) أو نظام (Design-Build) يؤثر على أداء المشروع من ناحية التكلفة والوقت.

من أجل مقارنة أداء مشاريع بين نظام (Design-Build) و نظام (Design-Bid-Build) من حيث الوقت والتكلفة لمشاريع البناء في المملكة العربية السعودية تم عمل هذه الدراسة التحليلة لعدد 44 مشروع تحت نظام (Design-Bid-Build) و11 مشروع تحت نظام (Design-Build) والتي تم الانتهاء من تنفيذها في المنطقة الشرقية من المملكة العربية السعودية خلال الفترة من 2011م الى 2018م وتكلفة هذه المشاريع أكثر من 10 مليون ريال سعودي تشمل تكلفة التصميم والتنفيذ ، وتشمل عدة أنواع من المشاريع: سكنية وتجارية وصناعية وتعليمية بالإضافة الى مشاريع البنية التحتية.

تم عمل التحليل الإحصائي للمشاريع عن طريق استخدام برنامج (XLSTAT) لتحديد ما إذا كانت المقاييس المتعلقة بالجدول والتكلفة تختلف بشكل كافي عن بعضها البعض في مشاريع (Design-Bid-Build) و(Design-Build).

بالإضافة إلى مقارنة زيادة نمو المدة الزمنية والتكلفة لمرحلة التصميم للنوعين من المشاريع (Design-Bid-Build) و(Design-Build) ، اظهرت النتائج أن مشاريع (Design-Build) تفوقت بشكل كافي وملحوظ على مشاريع (Design-Bid-Build) من حيث المدة الزمنية اللازمة للانتهاء من تصميم وتنفيذ المشاريع وذلك بشكل عام لكامل أنواع المشاريع التي تم تحليلها وبشكل خاص للمشاريع التجارية. وأظهرت الدراسة أيضا أن مشاريع (Design-Build) للمباني السكنية

تفوقت بشكل كافي على مشاريع (Design-Bid-Build) من حيث زيادة المدة الزمنية وتكلفة المتر المربع بالريال السعودي لمرحلتي التصميم والتنفيذ.

تتمثل المساهمة العامة لهذه الدراسة في توفير معلومات لمالكي مشاريع البناء في المملكة العربية السعودية بأن طريقة ترسية المشاريع باتباع نظام (Design-Build) ينعكس بشكل إيجابي على المدة الزمنية للمشروع خاصة للمشاريع التجارية والسكنية. بالإضافة إلى ذلك يمكن لمالكي المباني السكنية الى تخفيض تكلفة المتر المربع بالريال السعودي في حالة اختيار طريقة (Design-Build) عند ترسية المشاريع للمقاولين.

الهدف الثاني من هذه الدراسة هو معرفة سبب عدم استخدام طريقة ترسية المشاريع باستخدام طريقة (Design-Build) في مشاريع التنفيذ والبناء في المملكة العربية السعودية، وذلك نتيجة وجود عدد قليل من المشاريع التي تم جمع بياناتها لمشاريع (Design-Build) خلال المسح الميداني.

تم إجراء مسح ميداني لعدد 13 عامل مؤثر لعدم استخدام طريقة (Design-Build) من قبل مالكي المشاريع وذلك للحصول على اجابه من الخبراء والممارسين في مشاريع البناء والتنفيذ في المملكة العربية السعودية ، وتم تحليل نتائج العوامل المؤثرة وترتيب اهميتها باستخدام برنامج (SPSS) ، أظهرت نتائج التحليل الإحصائي أن أهم العوامل التي تؤثر على مالكي المشاريع لعدم استخدام طريقة ترسية المشاريع (Design-Build) كانت على التوالي: (1) عدم وضوح نطاق العمل للمالك من وقت مبكر (2) توقع المالك عرض سعر عالي من قبل المقاول عند استلام

عروض اسعار المقاولين (3) توقع المالك الكثير من أوامر التغيير خلال مرحلة التصميم والتنفيذ (4) قدرات فريق العمل التابعين لمالك المشروع .

توصي هذه الدراسة مالكي مشاريع البناء والتنفيذ عند اختيار نظام (Design-Build) بمزيد من الوضوح في نطاق العمل منذ وقت مبكر وتوفير فريق عمل مؤهل وذوخبره عالية وتقليل طلب الكثير من التغييرات أثناء التصميم والبناء.

CHAPTER 1

INTRODUCTION

Project delivery is a comprehensive process including industry planning, design, and construction required to execute and complete a building facility or other type of project. According to Miller et al. (2000), a project delivery system is a method for organizing and financing design, construction, operation, and maintenance activities and facilities the delivery of a good or services. since the end of the master builder, many delivery systems including Design-Bid-Build, multi prime, integrated project delivery, etc. have been implemented.

1.1- Statement of the Problem:

The delivery system in the construction industries in Saudi Arabia is one of the biggest factors that affect a project's performance negatively and approximately 70% are in Saudi Arabia Public Projects (Alzara et al. 2016).

Traditional delivery methods that are utilized in Saudi Arabia to select a contractor mostly depend on the lowest price and this type of delivery method affects the performance of the projects negatively in terms of time and cost (Alofi et al. 2016).

Assaf and Al-Hejji (2006) indicated that Saudi Arabian procurement system delivery methods lead to low performance for projects, due to the selection of delivery methods based on low cost. Performance assessment of project delivery methods; the Design-Bid-Build delivery system and the Design-Build delivery system may lead owners to better selection of a delivery system that positively affects the project performance (Ling and Kerh, 2004).

Clients always desire speedy project delivery, reduced project cost and a Design-Build delivery system that has a fast-track related to overlap between the design and the execution stages versus the Design-Bid-Build delivery system owner who will lead the design and execution stages and control all of the processes during the execution by a separate agreement with his consultant (Ghadamsi and Braimah 2011).

Lack of decision making by owners was a significant reason for the delay of execution projects in Saudi Arabia (Alzara and Kashiwagi and Sullivan 2016).
A Design Build delivery System will transfer all risk and responsibilities from the owner to the main contractor (Yates and Member 1995).

Recently, Saudi Arabia has had a high demand for execution project industries due to social economics, variations in government strategy and the demand for re-executing the infrastructure and all building facilities such as residential buildings, sports buildings, and offices. In addition, the private sector demands are affecting the government's strategy and the economy (Otaibi and Price 2010). Moreover, the largest execution project industries in the Middle East are in Saudi Arabia (World Execution, 2012).

Hashim Hammad (2016) cited that the Saudi Arabian Government is re-concentrating on building infrastructure, housing and transportation, due to the increasing population of Saudi Arabia.

The performance of time, cost, and quality is usually the measure of execution project success (Jeelani et al. 2012). A project delivery system is a contractual relationship to determine the rules and responsibilities for both the stages of design and execution.

Appropriate selection of a delivery system will positively affect the project performance. Design-Bid-Build and Design-Build are the two most common delivery systems in many countries (Jr et al. 2013).

Design-Build delivery system utilization in the U.K. in 2014 reached almost 40% (Plusquellec et al., 2017).

- In a Design-Bid-Build delivery system the owner has separate contractual relationships with both the designer and the contractor, v*ersus a Design-Build delivery system where the owner has a single agreement with one organization who handle the design and execution stages* (Chen et al. 2016; Titouan et al. 2017).
- In a Design-Bid-Build there is an absence of an adversarial relationship between contractors and consultants and owner integration and coordination between all of the project members is required *versus a Design-Build Build (D-B) that encourages an overlapping of the design and execution, leading to better communication between the designer and the execution (Shrestha et al. 2012;* Chen et al. 2016; Plusquellec et al. 2017*)*
- The contractor's selection of the Design-Bid-Build delivery system is based on the lowest price, except in the case of CM at risk where they have other criteria for selection *versus the Design-Build (D-B) owner's expectation of the contractors to provide the best value not the lowest cost* (Jeelani et al. 2012).

In any type of delivery method, time and cost are the measure of a project's success (Shrestha et al. 2012). There is no single delivery method that can be recommended to be utilized for every project. The selection of any project delivery method depends on how the project will perform for each method, so clients are required to select the appropriate delivery method for success depending on their project's level of complexity and challenge (Jr et al. 2013).

The most important consideration for a procurement system is how to divide the responsibilities and risk for all project participants. Over the years, multiple delivery systems have been developed which makes the best choice of delivery system for the clients more difficult (Bogus et al. 2013).

Lam et al. (2008) stated that Design build delivery systems have become more adoptable than before. Also they indicated in their regression analysis the integration between the project success index (PSI) and the success factors in delivering Design-Build Project and they reported that the success factors for a Design-Build delivery system, as per participant suggestion, were time, cost, quality and functionality.

The most important part that affects the success of Design-Build (D-B) is the project team. Second is the clients, and third is the contractor (Chan, A. et al. 2001). Lam et al. (2008) cited that the nature of the project and the project management action and approaches determine the success of a Design-Build delivery system. Songer and Molenaar (1997) cited that lack of experience leads to understanding the principle of the Design-Build delivery system in the long term for an execution project.

By contrast, a Design-Build delivery system has disadvantages related to the professional architect that may lead to poor design, because the contractor will have a conflict of interest during the design and execution (Yates and Member 1995).

This study may help the owner to distinguish the performance for both delivery methods in terms of time and cost, and lead to better selection of delivery methods for their projects.

1.2- Research Objectives:

- To evaluate and compare the performance between Design-Bid-Build (D-B-B) and Design-Build (D-B) in terms of time and cost for execution project industries in Saudi Arabia.
- To understand the reasons for not utilizing Design-Build Delivery methods in Execution Project Industries in KSA.

1.3- The significance of the research

Each project delivery system has several advantages and disadvantages for success. Performance Assessment will guide the client to better selection of an appropriate delivery system, either a Design-Build or a Design-Bid-Build delivery system.

1.4- Scope and limitations:

In this study the time and cost were limited; consequently the following limitations were imposed.

- It was limited to the completed projects from the last 8 years only, from 2011 up to 2018 and the project's budget limitation was more than 10 million Saudi riyals.
- 3) It was limited to the eastern region of Saudi Arabia only.

CHAPTER 2

LITERATURE REVIEW

Nowadays, multiple project delivery system methods are used to increase the efficiency of projects (Hale, Shrestha, Jr and Migliaccio 2009).

The most familiar and prevalent methods that are utilized in these projects are the DBB and the DB delivery systems (Konchar and Sanvido 1998).

Basically, the success of projects can be measured by attaining the right time and the optimum cost, by maintaining the quality of projects, and by considering client satisfaction, with health and safety as an important factor (Chan, A. et al. 2002).

Previous studies have discussed the performance between the BD and the DBB delivery methods for execution projects. This research will discuss the comparison between these delivery systems in terms of time and cost.

2.1- Design-Bid-Build Delivery Method

In a DBB delivery system, the client will have multiple agreements with the designer and the contractor (Jr et al 2013; Shrestha et al. 2012; Chen et al 2016). Architects and engineers will provide complete project documents; drawings, materials take off, and specifications, and issue these documents for the execution stage, then the owner will have a separate contract with the execution company after conducting contractors for the bid (Shrestha and Mani 2014). The owner will take time to receive bids from the execution company, make an evaluation, select the main contractor, and send the notice to proceed (No.TP). The selected execution company will start the execution of the project depending on the documents that are prepared by the design office/consultant for the projects (Hale et al. 2009).

The relationships between the owner and at least three organizations that are involved in executing a single project are shown in figure 01.

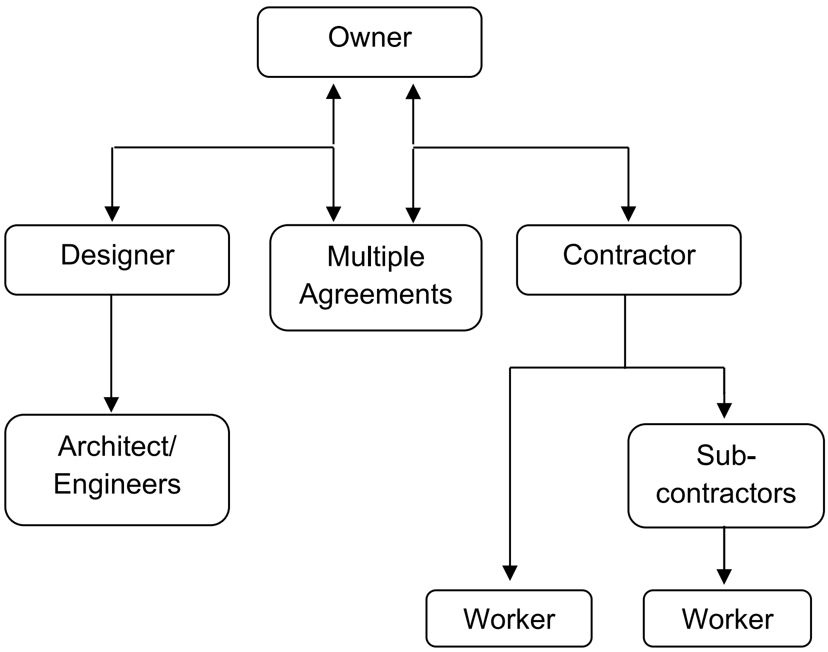


Figure 01 Procurement Method Relationships of DBB Projects (Stauffer G. 2006).

2.2- Benefits with consideration of Design-Bid-Build Delivery Method

Advantages	**Consideration**
Owner controls design and execution. (Ratnasabapathy and Rameezdeen 2005)	Requires significant owner expertise. The weak communication between designer and contractor during execution will affect project performance negatively (Shrestha and Mani 2014).

Owner have chance to change the design easily before start execution.	Owner delivers the project into two organizations for design and execution. Contractor starts the execution work after design completion (Plusquellec, et al. 2017).
Start of Execution after design completion (Gordon, 1994).	Contractor reviews project documents to eliminate the design error and the quality of drawings that prepare by designer affect projects performance (Shrestha and Mani 2014)
Owner's known execution cost upon contract award (Gordon, 1994). After design completion the owner submit RFQ for bids and upon receive the bids from contractor will usually deliver the project to one contractor (Plusquellec et al. 2017).	Any variation of design drawings during execution will consider as a Variation order (Shrestha and Mani 2014)
All project participants are involved during execution stage (Ratnasabapathy and Rameezdeen 2005)	Contractor not involved design, planning or value engineering (VE) and any Variation of design during execution lead contractor to raise a Variation order (Shrestha and Mani 2014)
Responsibilities are distributed between all project participants. (Ratnasabapathy and Rameezdeen 2005)	The owner select the contractor based on factors and insure of cost qualification or best value (Shrestha and Mani 2014)

Table 01, Benefits with consideration of Design-Bid-Build delivery system

2.3- Design-Build Delivery Method

The Design-Build (DB) is a single agreement where the contractor handles both stages; the design and the execution of the projects (Chen et al. 2016).

The two parties involved in the design-build are the owner and the contractor, as shown in figure 02. The selection of the Design-Build delivery system depends on the qualifications and the price of the contractor (Molenaar, et. al 1999), and may include all of the project stages such as design, procurement, execution and operation (Lee and Arditi, 2006).

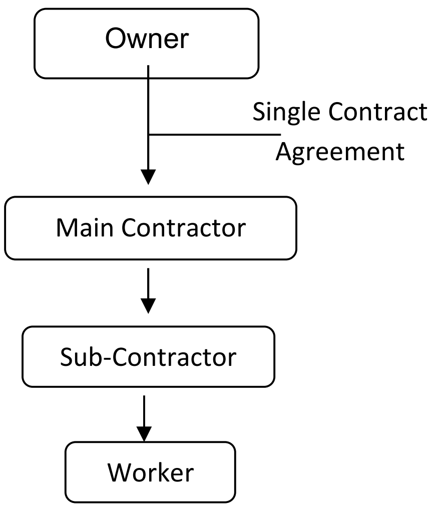


Figure 02 Procurement Method Relationships of DB Projects (Ling, 2004)

Songer and Molenaar (1997) selected a five-sequence process used for design build projects:

- Identify the delivery system to be design-build.
- Perform project coordination between project parties.
- Develop request for proposal (RFP) including all the documents.
- Perform proposal evaluation.
- Conduct contract administration.

2.4- Benefits of the Design-Build Delivery Method

Yates and Member (1995) indicated the benefits of the D-B delivery method;

- Minimize clashes between the participants in the project.
- Reduce disputes and variation orders over the project.
- Minimize the administrative tasks of the client and increase the ability to control the project.
- Reduce the duplicated tasks.
- Cash follow of the owner will be clearer and easier, and he can take decisions to minimize the project cost easily.

Comprehensive benefits of design-build delivery systems are shown below in table 02.

Advantages	**Considerations**
Single agreement is responsible for design and Execution (Chen et al. 2016).	Owner not much concern of design and execution quality and monitoring and these responsibilities will be transferred to one organization (Chen et al. 2016).
Project time will be reduced, due to early start date of execution stage before design completion (Chan, A. et al. 2002).	Matching project cost and completion date of the project before the contracted finish date is most important criteria to select design build (Songer and Molenaar 1997).
Estimated cost can be determined to the owner at earlier time (Chen et al. 2016).	Owner's expectation from contractor to provide best value not lowest cost (Chen et al. 2016).
Design Build (D-B) entity will load all risk for design and execution stages	Clear scope of work lead to display better implementation of the projects (Lam et al. 2008)
Emphasis on cost control (Chen et al. 2016).	Owner usually prefers to select contractor who has no disputes and claims in his previous projects (Ling, 2003).

Table 2, Advantages of Design-Build Delivery Method

2.5- Performance of DB and DBB Delivery Methods.

Contractor selection is the next step after the project delivery method is decided by the clients. Project outcomes, time, and cost performance lead the owner to select the qualified contractor. The owner prefers to select a contractor for a Design-Build who has previous project experience (Park and Kwak 2016).

The time and cost growth of project execution success depends on the appropriate selection of the project delivery system (Shrestha and Mani 2014; Hale et al. 2009).

2.5.1- Performance of time

Bidding duration and execution time growth determine the execution time (Chan, A. et al. 2002).

Time and the availability of resources are very important for the procurement of a design-build team (Bogus et al. 2013).

The main reason for selecting a design-build delivery system rather than another delivery method is that the duration of the project completion is the shortest when compared to other delivery systems (Chan, A. et al. 2002). Time is a key factor in the vast majority of execution projects, and it depends on the size and complexity of the projects (Chen et al. 2016).

Alofi et al. (2016) cited that the Government Bidding System in Saudi Arabia depends on the traditional delivery method of Deign-Bid-Build as per the following procedure:

- Proposal Submission under the public procurement competitions with announcement and determination of the date for preparing the bids, the deadline, and place of bids submittal.
- Determine the place and date for the opening bids.

The Design-Bid-Build delivery method is performed by two entities; the designer and the contractor. The designer prepares the drawings and specifications and the contractor will start the execution stage after completion of the design stage. A Lack of communication between the designer and the contractor due to design error in the execution stage will affect the performance of the project negatively in terms of time and cost (Shrestha and Mani 2014).

In the Design-Build delivery method the constraints of the procurement team are how to combine the conflict of procurement methods such as qualification and price. **The** Request For Proposal (RFP) for design teams should be clear, specific and contain the vision of the owner, due to the fact that the design is not finalized at the time of procurement (Bogus et al. 2013).

Plusquellec et al. (2017) compared the time and cost performance between the Design-Build and the Design-Bid-Build for different types of complex facilities in military execution and the sample of the project was 278 Design-Build and 557 Design-Bid-Build. The result also mentioned that the time performance for DBB has more advantages in total project duration.

Chen, Jin, Xia, Wu, and Skitmore (2016) indicated that, in regards to the performance time for Design-Build projects, the reason for on-time design-build completion is the impossibility of overlap between the design and the execution stage.

Design-Build projects can be run with fast-track execution and started before the completion of the full design documents. 80.4% of the projects started as per the start date that was mentioned in the contract. Whereas only 14.8% started late.

Completion on time is one of the most desired results for project execution. The design build contract completion date is lower than that of the design-bid-build delivery system (Hale et al. 2009).

Chen et al. (2016) concluded that 23.1% of the Design-Build (DB) projects exceeded the planned time, 33% of the projects were delivered as per the planned time and the remainder of the projects, with a percentage of 43.9%, were delivered ahead of time.

Ling (2003) stated that focusing on the project completion date during the execution for Design-Build (DB) projects will adversely affect the speed of the project, because the contractor will be under pressure to finalize the project on time which causes the defects to be re-worked. The design stage is a vital stage that affects the whole duration of the project and the owner should not take too much time for completion.

2.5.2- Performance of cost.

The owner's expectation from contractors in the DB delivery method is to increase the value of the projects without focusing on the project cost (Chen, et al. 2016). Design-build projects increase the project cost in comparison with design-bid-build projects (Jr et al. 2013).

Traditionally, most of the projects will have variation orders during the design and execution stage, and the most important matter is how to eliminate or minimize these variation orders.

The cost growth (CG) for design-bid-build is double the cost growth for the design-build (Hale et al. 2009). The owner usually prefers to select a contractor who has no disputes and claims in his previous projects (Ling, 2003). The negotiation of claims in a design-build project is considered to be an advantage because the owner will negotiate with a single organization.

The estimated cost of the project can be determined by the owner at an earlier time. The variation order that increases the cost will be decreased because the design build methods can control the total cost over the design, scope and budget. However, the owner's expectation from the Design-Build contractors is to provide the best value and not the lowest cost (Chen et al. 2016).

A design-build delivery system can minimize the claims, and a variation order can impact the total cost, decrease the duration of the project and increase the efficiency between the project parties (Lee and Arditi, 2006).

2.5.3- Performance of DB and DBB in regards to time and cost.

A performance comparison for both delivery systems is made: Design-Bid-Build (D-B-B) and Design-Build (D-B) in regards of time and cost. Hale et al. (2009) determined the performance of DB and DBB projects from 1995 to 2004 in the United States for buildings, to identify the best project delivery method in terms of time and cost. The comparison of time growth and cost growth was made for 39 D-B-B completed projects and 38 D-B completed projects. Time growth was compared statistically with project time with the information of the original project start date and the project completion date. Cost growth compares the cost per bid with the original contract cost and final contract cost. The purpose of the study is to find which project delivery method is superior (DBB versus to DB).

Total contract cost growth and time growth were evaluated by using ANOVA to determine the mean, median and standard deviation. The conclusion of mean, median, and standard deviation was a lower bid cost and cost growth for D-B projects when compared with D-B-B projects, while the time growth of D-B-B projects was higher than for D-B projects. Cost Growth for D-B projects is superior to D-B-B projects, cost growth for D-B and D-B-B projects was, respectively, 2% and 4%. Moreover, the project duration of D-B and D-B-B projects were (667 days for D-B versus 1398 days for D-B-B), year duration (864 days for D-B versus 1064 days for D-B-B), and execution start duration (667 days for D-B versus 771 days for D-B-B). The results showed that D-B projects take less time and have less cost growth in comparison to D-B-B projects.

Another study by Minchin Jr et al. (2013) compared the performance of the most used delivery system for 30 projects using DBB and 30 projects using DB for highway and bridge execution with a budget of at least 7 million dollars between 2002 and 2010. The study method used statistical analysis of the data collected from the Florida Department of Transportation (FDOT) website. The study estimated the values, contract award cost, actual cost, original contract duration and final duration of completed projects by using Levene's test, the unequal samples t-test, the Welch unequal variances t-test and the Mann-Whitney U tests to compare the percentage error between the original estimate and final contract price.

The study's preliminary results showed that the standard deviation for the largest difference between the original cost estimated and the awarded cost of DBB projects was 32.68%, while 12.55% was the average error. Also the final duration was higher than the contract duration by at least 2.74%.

The study compared the percentage error between the original estimated cost and the awarded contract price for D-B and D-B-B. The result showed the mean and standard deviation for the DB project to be, respectively, 108.47 and 284.03, and for DBB, 12.55 and 33.24.

The variances between the DB and DBB projects was unequal; the level of the Levene's test was p=0.004 less than 0.05.

Similarly, the t-test compared the percentage error between the original estimated cost and the final contract price for DB and DBB. The result showed the mean and standard deviation for the DB project to be, respectively, 135.371 and 324.304 ,and for DBB, 20.423 and 40.138.The variances between the DB and DBB projects was unequal; the level of the Levene's test was p=0.004 less than 0.05.

Another unequal sample t-test and the result after calculated that the variances of the percent error between the original and the award contract price for DB and DBB projects was not the same; the level of the Levene's test was p=0.004 less than 0.05. The study concluded that the reliability of DBB in terms of cost by using arithmetic analysis was lower than DB. However, the DB performance in terms of time was a little bit better than for DBB.

Shreshtha et al. (2012) determined the performance metrics of time, cost, and variation order for DB and DBB large highway completed projects that cost more than 50 million dollars in the Texas Department of Transportation. The sample size was 6 DB projects and 16 DBB projects.

The performance of time, cost, and variation order growth was compared statistically for both delivery methods; DB and DBB.

The results indicated that the DB project was statistically significantly faster than the DBB projects for both speed of execution and project delivery per lane kilometer.

The summary of the comparisons between the DBB and the DB delivery method is shown in table 03.

Researchers	**Methods**	**Sample Size**	**Project Types**	**Major Findings**
Hale et al. (2009)	DB DBB	38 39	Buildings	DB Time and cost growth were lower than that of DBB
Jr, Li, Issa and Vargas (2013)	DB DBB	30 30	Highway and bridge	DB is superior to DBB in term of time and not better in term of cost.
Hale D. R, (2005)	DB DBB	37 38	Public sector Buildings	DB Time and cost growth were lower than that of DBB
Shreshtha et al. (2012)	DB DBB	5 16	large highway	DB project were statistically significant faster than DBB projects for both speed of execution and project delivery per lane kilometer

Table 03, The Summary of comparisons between DBB and DB delivery methods

2.6- Factors that impact DB project success.

The success of execution projects is repeated (Ashley et al. 1987). There are some studies that conduct project success factors.

Chan et al. (2001) indicated that owners, contractors, and the commitment of the project team contributed to project success. Contractors perform the time of projects, while the project team perform the time and cost and the design quality.

The clients are one of the project participants that provide the success of DB projects. The owner, contractor and project team lead to project success by performing the following activities: (1) Rapid decisions by the owner to instruct their team to respond to the questions to RFP during the estimation time (Bogus et al.2013); (2) The capabilities of the owner's team to manage and control design work to provide a chance of success in DB projects; (3) The clearly defined scope of work is the most critical factor for a Design-Build project's success (Songer and Molenaar, 1997; Lam, et al. 2008); (4) The owner should make sure that the scope of work for the DB delivery method is specific and clear before inviting contractors for bids. (Ling 2003).

The owner is not very involved in the project stages. Some of the advantages of the DB delivery method are minimizing the administrative task of the client and increasing his ability to control the project, as well as reducing the duplicated tasks. (Yates 1995).

Chan, A. et al. (2002) defined quality for DB projects as meeting the owner's requirements and expectations in terms of materials, workmanship, technical aspects, functional aspects and architectural aspects.

Songer and Molenaar (1997) sorted the success criteria of the DB delivery method: matching project cost, and concluded that the completion of a project as per the contracted date was the most important criteria of the DB delivery method. The success of any project can be determined by the performance of the cost, time and quality aspects (Lam et al. 2008). Ling (2003) also added the satisfaction of the owner's requirements.

The short duration of the contractor's bid affects the cost performance negatively during the procurement time (Bogus et al. 2013).

Monitoring the time and cost of projects is the most common criteria that affects DB success (Chan, A. et al. (2002)). Bogus et al. (2013) cited that the project participants' team work, as well as time, cost, and quality performance is a key part of DB success, and that this is either the contractor's or the owner's responsibility.

Contractors should have the capability to export good design and work management. The clarity of the scope of work by the owner provides a chance for success in DB projects and reduces the variation order during the execution stage by the owner (Chan et al. 1999).

Lee and Arditi (2006) stated that one of the DB advantages is maintaining quality for the project by minimizing the claims, variation order that impacts the total cost.

Bogus et al. (2013) cited that the most critical factors that affect the project performance are the following; prequalification of the project participants such as the experience and the previous reputation of the contractor and project management action, technology and planning.

Bogus et al. (2013) also cited that prequalification of the project participants, such as the experience and the previous reputation of the contractor, was the most critical factor that affects project performance. Chan et al. (2001) arranged the importance of the factors that contribute to the success of a DB project, respectively as follows: commitment of the project team contractor's competencies and experience.

Ling (2003) indicated that project completion by the contractor on time within the estimated budget, and maintaining project quality are the most important factors that affect the performance of DB projects. Selection of the contractor based on their capabilities is the key to DB project success.

Alofi et al. (2016) cited that the Government Procurement System in Saudi Arabia depends on the traditional delivery method for a DBB as per the following procedure:

- Proposal Submission under the public procurement competitions with announcement and determining the date of the pre-bid, the deadline, and the location for submitting bids.
- Determine the location and date of the opening bids.
- Winning contractor selection based on low price.

Alofi et al. (2016) analyzed low performance attainment when using the current Saudi procurement system. A survey was conducted to clarify the Performance Information Procurement System (PIPS) into the current procurement system in Saudi Arabia to solve the continuous low performance in their projects. The study reviewed the current project delivery system (DBB) in Saudi Arabia and compares it with the Performance Information Procurement System (PIPS). The participants who responded to this survey numbered 245 out of 664. The experience of the respondents included multiple experience from 4 to 16 years and most of the project parties; 157 engineers, 33 consultants, 9 owners, 5 venders, 13 academics and 28 architects for a common project in Saudi Arabia such as buildings, healthcare projects, industrial etc..

The study showed that 80.61% of survey participants believe that selecting a contractor with poor performance is due to the traditional delivery system which is utilized in Saudi Arabia. Furthermore, selecting the contractors based on the lowest bid leads to poor project performance, and close to 96% of participants believe that. Approximately 41% of survey participants strongly agreed with identifying the risk by contractor and resolving all of the clients' clarifications before signing the contract improves project performance, 48.02% of the participants agreed to identify the risk as being before the contract is signed, 3.93% disagreed, almost 8% of them were not sure, and 48% agreed to resolve all clarifications that are raised by clients. Around 70% of participants strongly agreed that the contractors have to prepare a time after receiving the notice to proceed (No.TP), prior to decrease the loss of time and cost, and 26.14% agreed.

In addition, the study recommended upgrading and improving the performance behavior of the Saudi Arabian Procurement System by selecting expert contractors to improve the performance level and evaluate the expert contractors by requesting them to submit their plan and identify risk, as well as resolving all of the clients' concerns before signing the contract.

CHAPTER 3

RESEARCH METHODOLOGY

This chapter presents the steps that were followed to achieve the objectives that are set for the study. The required data, data collection, and data analysis are presented in the following sections:

3.1- Required Data

The performance assessment of the Design-Bid-Build and the Design-Build delivery methods necessitate the availability of the following data:

Execution time can be measured by project procurement duration and project performance in terms of time (Chan, A. et al. 2002).

Planned Time is the period from the planned start date to planned completion date for the design and execution stages, either for the Design-Bid-Build or the Design-Build delivery system.

Planned Time Growth = [(project duration as per actual – project duration as planned) / project duration as planned] x 100%.

Final Time is the period from actual start date to actual completion date for the design and execution stages, whether for Design-Bid-Build (D-B-B) or Design-Build (D-B) Projects.

Final Time Growth = [(Total duration as per actual – Total duration as planned) / Total duration as planned] x 100% (Bogus, Migliaccio, and Jin, 2013).

Productivity (m2/day) = Build up Area / Total time per day (Ling 2003).

The relationship between project procurement duration (PD) and project performance in terms of cost by using an equation to calculate the cost growth (CG) percentage:

Contract Cost Growth = [(project cost as per actual – project cost as contracted) / project cost as contract] x 100%.

Final Cost Growth = = [(Total Cost as per actual – Total cost as contracted) / Total cost as contracted] x 100% (Bogus, Migliaccio, and Jin, 2013).

Unit Cost (SR/m2) = Final Cost / Build up Area (Ling 2003).

The determination of the factors hindering the implementation of the D-B delivery system necessitates the listing of potential factors that were listed in the literature review.

3.2- Data Collection

The performance assessment data were obtained from their primary sources through a structured form which was developed for this purpose. The form consists of three parts: the first part consists of variables describing projects such as project name, location, project participants (Owner, and Contractor), built area, execution year, etc. The second part consists of project characteristics related to time, cost, and variation order. A copy of the developed form for a DB and a DBB project is found in Appendix A.

A survey will consist of two sections: the first section will have separate data collection for DBB and DB projects in the Eastern Province of Saudi Arabia from completion projects in the public and private sectors and for both types of delivery systems: the Design-Bid-Build (DBB) and the Design-Build (DB) delivery methods, in order to compare the performance as precisely as possible between the two different delivery methods: DBB and DB.

The data collection of project data consists of general information about the projects (Name, Location, Name of Contractor/Consultant/Owner, Build up Area, execution year and etc.). The second part consists of variable information from completion projects related to cost, time and variation order for two types of delivery method, DBB and DB, to evaluate the performance comparison of the projects in terms of time and cost, and include the performance metrics for time, cost and variation order to the time and cost.

The collected information of the time and cost for Design-Bid-Build was separate for design and execution. However, for Design-Build the project data for design and execution were combined for time and cost.

The required data for the factors hindering the implementation of a DB delivery system in Saudi Arabia were collected from experts in the execution industry (Owner, Consultant, and Contractor) through a structured questionnaire. The questionnaire consists of two sections.

The first section consists of questions seeking information about the respondent, such as education level, experience in execution industry, etc.

The second section consists of a list of potential factors that hinder the implementation of a DB delivery system in Saudi Arabia.

A measuring scale uses the Likert scale from 1 to 5 where 1 strongly disagree factor, 2 disagree factor, 3 neutral factor, 4 agree factor, & 5 strongly agree factor. Set next to each factor for a participant to measure the level of resistance to implementation. A copy of the questionnaire is located in appendix B.

3.3- Population and Sample Size

The target population to collect project data and characteristics (Time, Cost, and Variation Order) for DB and DBB projects will include the local and international project management teams (Clients, Consultants, and Contractors), who is working in Saudi Arabia, in the Eastern Province for both the public and private sectors that have executed and completed projects in the last eight years.

List of public sector organizations: (1) Ministry of Municipal and Rural Affairs (MOMRA) for buildings and infrastructure projects; (2) Saudi Electrical Company (SEC); (3) Saline Water Conversion Corporation; (4) Saudi Ports Authority.

List of private sector organizations: (1) Real-estate Development Organization; (2) Charity Organization; (3) Industrial Organization; (4) Commercial Organization; (5) Oil and Gas Organization.

The criteria that are used to select the data for the time and cost for DBB and DBB construction projects were (1) the projects should be completed and operated from 2011 to 2018; (2) the project type was buildings; residential, commercial, institutional, industrial, as well as the infrastructure projects; (3) the projects should be executed in the eastern province of Saudi Arabia; (4) the project's budget is more than 10 million Saudi riyals.

The collected project information was from first classified contractors in MOMORA and notable companies with primary headquarters organizations in the eastern province. It was necessary to add second and third classified contractors and some private organizations in the market and to include a few projects that have a budget of less than

10 million Saudi riyals, due to the fact that there were many obstacles and constraints during data collection, especially for Design-Build projects such as their ability to provide secure data for cost and time and finding the free time to fill and complete the questionnaire. In addition, sometimes a project's file was lost, as well as the main obstacles and secure information for oil and gas organizations in the eastern province, as well as the fact that the DB project under the EPC contract was for mechanical and electrical work, not for buildings. However, many of the project participants in classified contractor and headquarters organizations assisted with providing the data of time, cost, and variation order data for their projects.

Due to the limitation in the numbers of Design-Build delivery systems for building construction projects in Saudi Arabia, when compared with the Design-Bid-Build delivery method as per the information that is collected during the survey, as well as the lack of using the Design-Build delivery system of small businesses (USDOT 2004).
Hence, the study was expanded into a questionnaire to know the factors that hinder the implementation of a DB delivery method in Saudi Arabia.

The government of Saudi Arabia considers that oil revenues will fall by about 42%by 2023. The number of public companies on the Tadawul is 10 companies.
(https://en.wikipedia.org/wiki/List_of_companies_of_Saudi_Arabia)
The total number of classified contractors under the first categories in the eastern province were 5 contractors for building and infrastructure projects in 2018 and they conducted projects with a budget of more than 280 million SR (https://www.momra.gov.sa/GeneralServ/statistic.aspx).

To make sure that the sample which is taken for factors that hinder the utilization of a DB project was a statistically representative sample for the population of eastern province building contractors, the formula shown in Equation 1 was used (Hogg et al. 2015).

$$n = \frac{m}{1 + (\frac{m-1}{N})} \qquad (1)$$

Where: n represents the sample size of the limited, m represents the sample size of the unlimited and N represents the sample size of the available Population. On the other hand, m is estimated by Equation 2.

$$m = \frac{z^2 \times p \times (1-p)}{\varepsilon^2} \qquad (2)$$

Where: z is the statistic value for the confidence level used, as shown in the below table.

Confidence level	**Z value to be used**
99%	2.575
95%	1.96
90%	1.645

Table 04, confidence level related to z value

P = the value of the population proportion.

ε = the sampling error, if p value is unknown.

Sincich *et al.* (2002); Hogg et al. (2015) suggested a conservative value of 0.50 be used so that a sample size that is at least as large as required is obtained.

Using a 95% confidence level, that is a 5% significance level, the unlimited sample size of the population, m is determined by Equation 2 as follows:

$$m = \frac{(1.96)2 * 0.50 * (1-0.50)}{(0.05)2} = 385$$

Therefore, for the total number of 17 classified contractors under the first categories and numbers of notable companies with primary headquarters located in the eastern provinces is 10 companies, i.e. *N*, the representative sample size of the population required is quantified by Equation 1 as shown below:

$$n = \frac{385}{1+\left(\frac{385-1}{15}\right)} = 385/26.60 = 14 \text{ companies.}$$

3.4- Data Analysis

The collected data was analyzed to determine the mean, standard deviation, and hypothesis testing using a statistical package.

The collected data will be analyzed using an XLSTAT and an SPSS package program. The mean, median, standard deviation and ANOVA will be calculated to determine the performances of the Design-Build and Design-Bid-Build delivery methods.

Analyzing the factors that hinder the implementation of a DB delivery system by using an SPSS package and determining the mean and standard deviation to determine the rank of the importance influences that affect the selection of a DB delivery system in execution project industries.

CHAPTER 4

RESULTS ANALYSIS

In the second quarter of 2017, the questionnaire was sent and distributed to owners, consultants and contractors in the eastern province of Saudi Arabia.

Fifty Five (55) questionnaires were collected from project participants; owners and contractors. Forty Four (44) were for Design-Bid-Build projects and Eleven (11) for Design-Build projects.

Data collections of project data were for different building types such as residential, institutional, commercial and industrial buildings, as well as infrastructure projects that were delivered under DBB and DB delivery systems.

Project information and data characteristics for all Fifty Five (55) projects were reviewed and entered into an excel sheet file prior to performing the statistical test in terms of time and cost.

All data for time and cost was statistically analyzed by using the ANOVA test, a t-test, and Analysis of Variances. The statistics program used in this study is EXCEL after adding XLSTAT to create the statistical analysis.

The normality hypothesis will be refused and stated with a 95% confidence interval on the ratio of variances, if the p-value is equal to or less than the alpha level 0.05. But, if the hypothesis of normality is not rejected, this study is required to be stated with a normal distribution.

This study supposed unequal variance with a normal distribution and the t-test is used to identify the significant difference between two way samples.

This research also studies the factors hindering the implementation of a DB delivery system in Saudi Arabia and starts with a deep literature review about the factors that affect not utilizing a Design-Build delivery method for execution project industries. The questionnaire was structured based on time and cost influences with 15 questions regarding not utilizing a Design-Build delivery method. After that a round of 4 interviews was done with 4 experience project managers and 4 questions were distributed in order to check and assess the clarity, interpretation, appropriateness, and comprehensibility of the questions, and to determine the efficiency of the questionnaire. After that the number of questions was reduced to 11 questions and two multi-choice questions about their previous experience of Design-Build delivery method and the range of their satisfaction. Then it was published online on Monkey survey, after which it was distributed by email and social media. Also hard copies were distributed to the targeted site engineers, project engineers, execution Managers, Project Managers, and General Managers. Then the 54 responses were summarized into the Statistical Package for the Social Sciences (SPSS) which is statistical software.

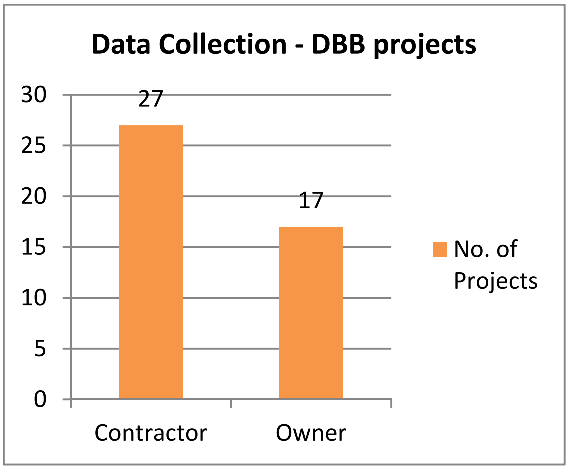
4.1- Characteristics of Participants

This research aimed to compare the Design-Build versus the Design-Bid-Build delivery system in Saudi Arabia. The collection data for time and cost in this research included 27 DBB projects by contractors, and 17 DBB projects by owners, 8 DB projects by contractors, and 3 DB projects by owners, as shown in Figures 03 and 04.

13 owner's respondents and 24 contractor's respondents work in public and private sectors with an interest in the project delivery system for DB and DBB projects and

provided projects data and characteristics. 10 projects were neglected from the study due to the fact that there was missing data for project time, and cost or variation order, in regards to the design or execution stage.

Figures 05 and 06 show the percentage of respondent's professions that provided project data and characteristics for both delivery methods: DB and DBB.



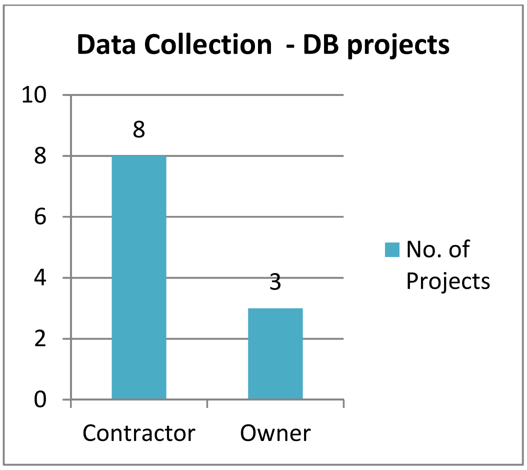
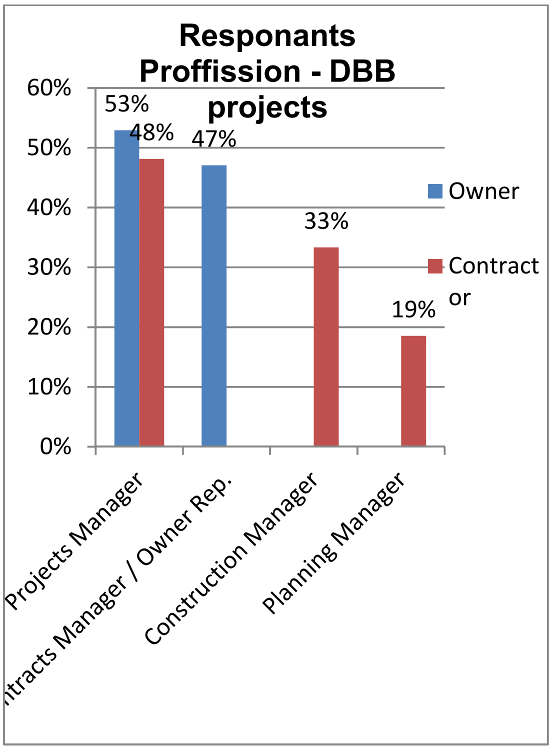


Figure 03, Data Collection for DBB

Figure 04, Data Collection for DB



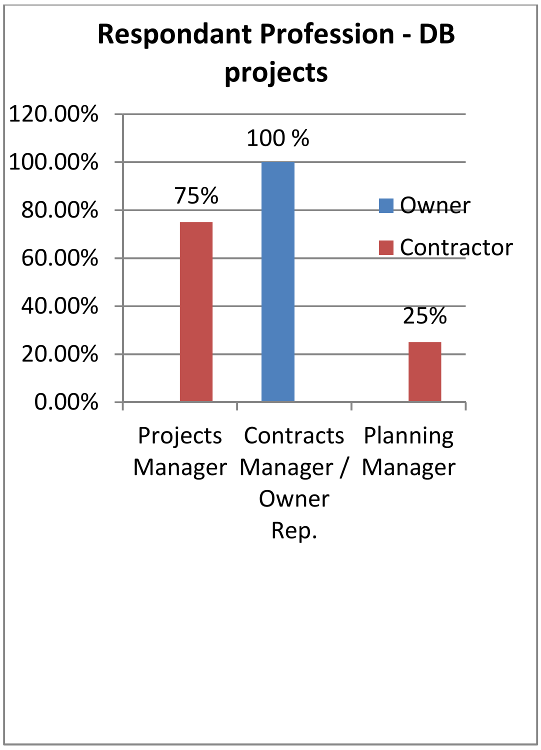


Figure 05, Respondent's Profession DBB   Figure 06, Respondent's Profession DB

Factors hindering the implementation of a DB delivery system were administered in this research to hinder the implementation of a DB delivery method in execution project industries in Saudi Arabia.

The collected information was from 54 engineers, 20 owners, 11 consultants, 23 contractors. 54 out of 123 participants who work in public and private sectors submitted their needful responses through the questionnaire, as shown in figure 07.

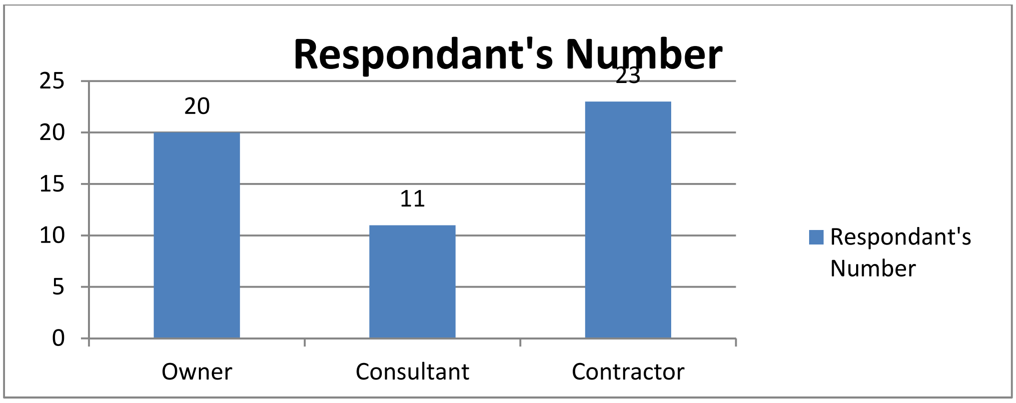


Figure 07, Respondent's Number per project participants.

Figure 08 shows the years of experience for the participants; 23 participants had between 5 to 10 years of experience, 14 participants had between 10 to 15 years of experience, 8 participants had between 15 to 20 years of experience, 6 participants had less than 5 years of experience, 2 of participants had between 20 to 25 years of experience, and one participant had more than 25 years of experience. All participants have practical experience in the most common types of execution such as residential, commercial, and industrial buildings, as well as infrastructure projects.

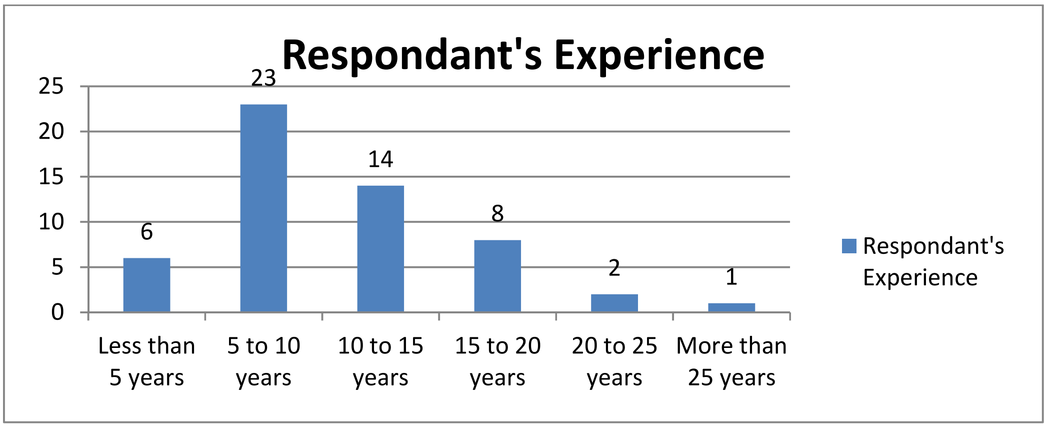


Figure 08, Respondents experience in execution industry field in year.

4.2- Characteristics of Projects

The data collected for the projects were for execution industries that delivered using two different types Design-Bid-Build (DBB) and Design-Build (DB) delivery methods for both the government and public sectors.

Figures 09 and 10 show the maximum number of DB and DBB projects that were collected from the eastern province of Saudi Arabia for both the public and government sectors. The maximum number of DBB and DB projects was for the public sector 28 projects for the DBB delivery method and 8 projects for the DB delivery method. In addition the figure shows that the number of government projects for the DBB delivery method was 16 projects, while for the DB delivery method it was 3 projects.

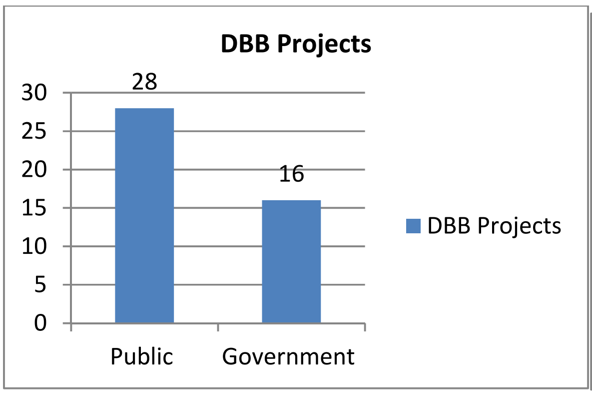


Figure 09, Number of DB projects

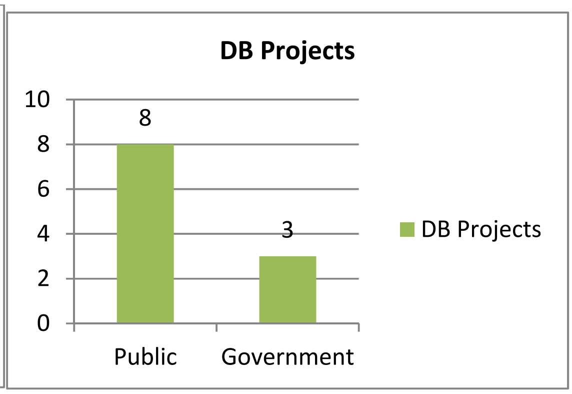


Figure 10, Number of DBB projects

Figures 11 and 12 show the maximum number of DB and DBB projects by building types for both the public and government sectors.
Residential, institutional, industrial, commercial, and infrastructure were the execution types for the DBB and DB projects. The maximum project number is for the residential and institutional building types for DBB projects and infrastructure for the DB projects. By contrast, the minimum project number is the infrastructure building type for the DBB projects and residential for the DB projects.

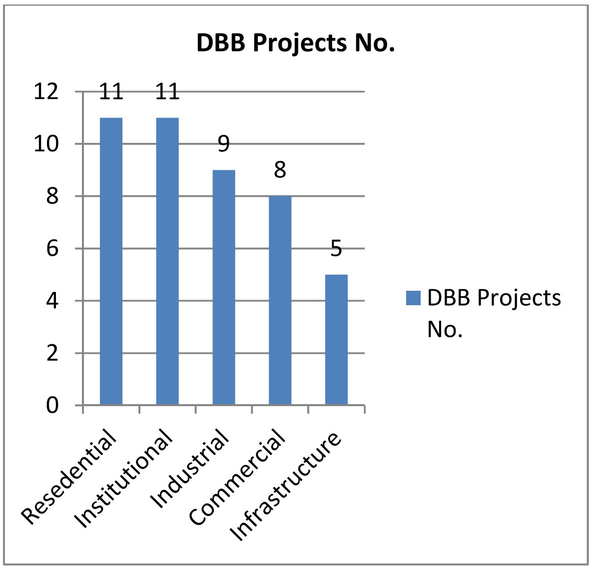


Figure 11, Building types of DBB projects.

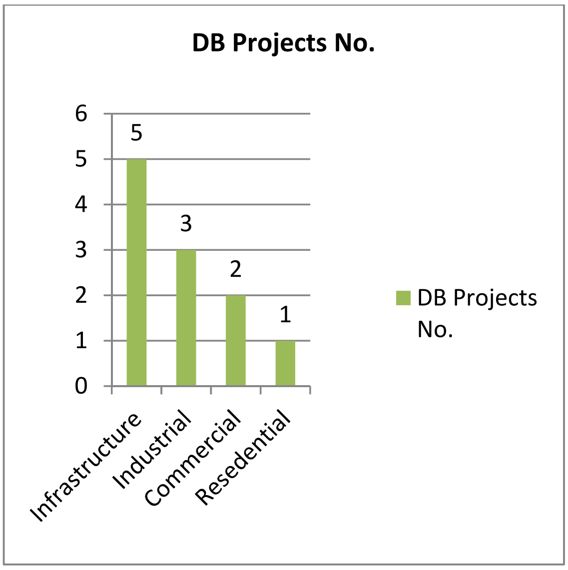
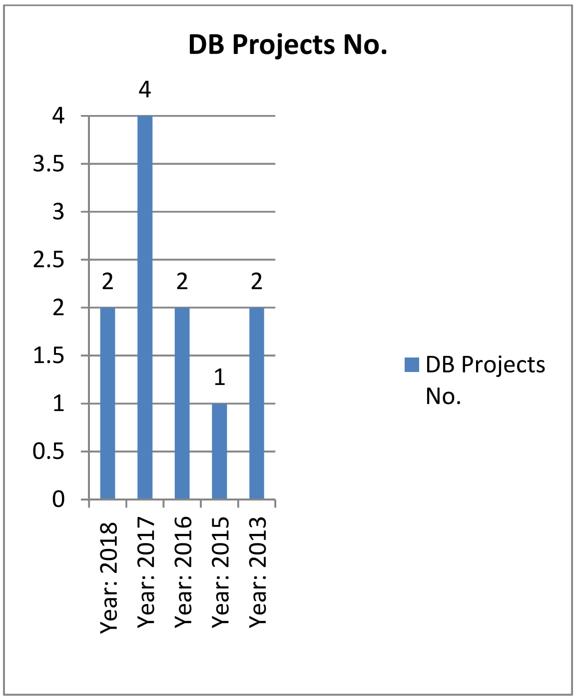


Figure 12, Building types of DB projects.

Figures 13 & 14 show the completion date by year for total number of projects in the DB and DBB projects. These figures indicate that the highest numbers for both the DB and the DBB projects was in 2017, while the lowest number for the DB projects was in 2015 and for DBB it was in 2011.



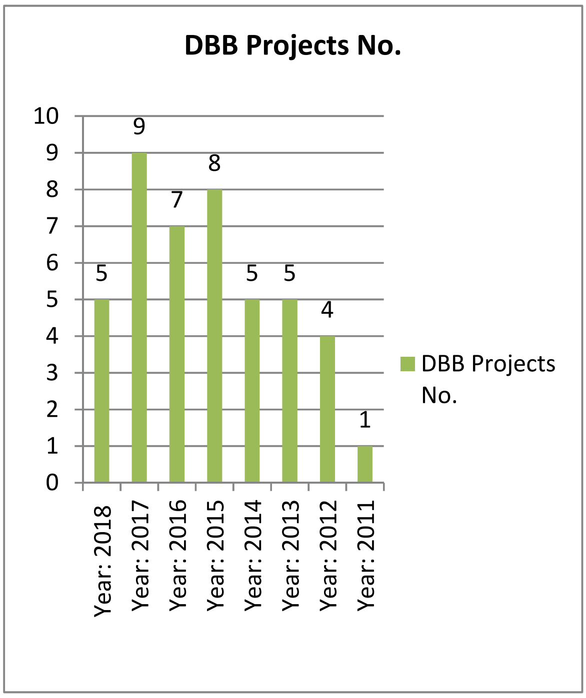


Figure 13, Completion date of DB projects. Figure 14, Completion date of DBB projects.

Figures 15 & 16 indicate the total budget for the executed DB and DBB projects. Around 55% of the DB projects had a budget range of more than 100 million Saudi Riyals and 27% of the projects had a cost range between 20-100 million Saudi Riyals. Only 18% of the project cost range was less than 20 million Saudi Riyals.

By contrast, the highest cost range percentage (56%) for DBB projects was between 10 and 50 million Saudi Riyals, and the lowest cost range percentage (14%) was less than 10 million and between 50 and 100 million Saudi Riyals. About 40 % of the DBB projects cost range was more than 100 million Saudi Riyals.

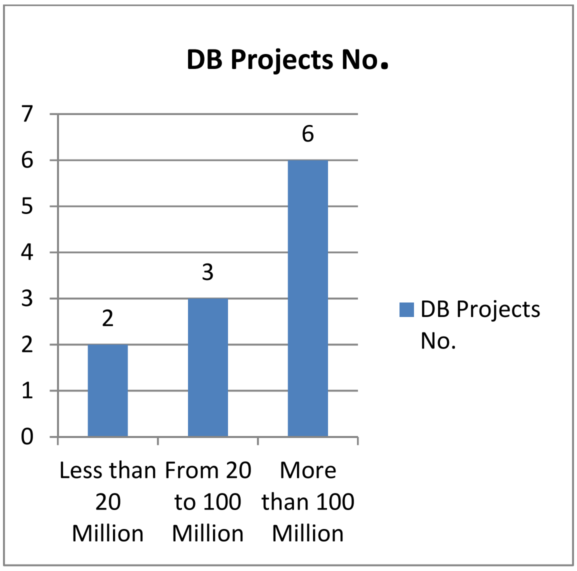


Figure 15, Total Budget of DB projects.

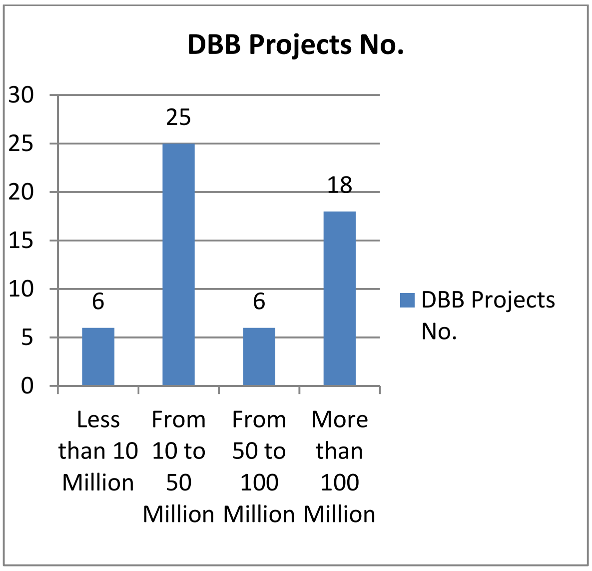


Figure 16, Total Budget of DBB projects

4.3- D-B-B and D-B Projects Performance

To compare the performance of time and cost for the DBB and DB delivery methods for both government and public projects, we developed an equation formula from the literature review to calculate the time and cost growth.

$$\text{Design Schedule Growth (\%)} = \frac{\text{Actual Design Duration} - \text{Planned Design Duration}}{\text{Planned Design Duration}} \text{ x } 100 \text{ .... } (3)$$

$$\text{Construction Schedule Growth (\%)} = \frac{\text{Actual Execution Duration} - \text{Planned Execution Duration}}{\text{Planned Execution Duration}} \text{ x } 100 \text{ .... } (4)$$

$$\text{Total Schedule Growth (\%)} = \frac{\text{Actual Design and Execution Duration} - \text{Planned Design and Execution Duration}}{\text{Planned Design and Execution Duration}} \text{ x } 100 \text{ .... } (5)$$

$$\text{Productivity } \left(\frac{\text{m2}}{\text{day}}\right) = \frac{\text{Total Build up Area of the Project}}{\text{Total Project Duration}} \text{ .... } (6)$$

$$\text{Change Order Cost Ratio (\%)} = \frac{\text{Total Variation Order Cost}}{\text{Total project Cost}} \text{ x } 100 \text{ .... } (7)$$

For Design-Build (DB) projects, time data will combine design and implementation duration. But for Design-Bid-Build (DBB) projects, data will be separated for design and execution.

$$\text{Design Cost Growth } (\%) = \frac{\text{Final Award Cost for Design} - \text{Contract Cost for Design}}{\text{Contract Cost for Design}} \text{ x } 100 \text{ .... } (8)$$

$$\text{Construction Cost Growth } (\%) = \frac{\text{Final Award Cost for Execution} - \text{Contract Cost for Execution}}{\text{Contract Cost for Execution}} \text{ x } 100 \text{ .... } (9)$$

$$\text{Total Cost Growth } (\%) = \frac{\text{Final Award Cost for Design and Execution} - \text{Contract Cost for Design and Execution}}{\text{Contract Cost for Design and Execution}} \text{ x } 100 \text{ .... } (10)$$

$$\text{Change Order Cost Ratio } (\%) = \frac{\text{Total Cost for Variation Order}}{\text{Contract Cost for Design and Execution}} \text{ x } 100 \text{ .... } (11)$$

$$\text{Cost per Square Meter } \left(\frac{\text{SR}}{\text{m2}}\right) = \frac{\text{Final Award Cost}}{\text{Total Build up Area}} \text{ .... } (12)$$

The total combined project data, as well as the time and cost growth performance, are shown in Appendix No. 01.

4.3.1- Hypothesis Testing

Null Hypothesis

This study assumes that the mean of the two variables is the same as per the null hypothesis to calculate the statistical test.

1- The mean of Time Growth for Design and Construction in DB Commercial Projects is equal to the mean of the DBB Commercial Projects.

μ Time Growth for Design and Execution in Commercial DB = μ Time Growth for Design and Execution in Commercial DBB .... (13)

2- The mean of Productivity in DB Commercial Projects is equal to the mean of DBB Commercial Projects.

μ *Productivity in DB Commercial Projects =* ***μ*** *Productivity in DBB Commercial Projects …………………………………………………………………………….…… (14)*

3- The mean of Cost Growth for Design and Construction in DB Commercial Projects is equal to the mean of the DBB Commercial Projects.

   μ *Cost Growth for Design and Execution in Commercial DB =* ***μ*** *Cost Growth for Design and Execution in Commercial DBB ……….……………………….….… (15)*

4- The mean of the Cost Growth Ratio for Variation Order Ratio in DB Commercial Projects is equal to the mean of the DBB Commercial Projects.

   μ *Cost Growth Ratio for Variation Order in Commercial DB =* ***μ*** *Cost Growth Ratio for Variation Order in Commercial DBB ………………………….…… (16)*

5- The mean of the Cost per Unit in DB Commercial Projects is equal to the mean of the DBB Commercial Projects.

   μ *Cost per Unit Commercial DB =* ***μ*** *Cost per Unit in Commercial DBB ………….……………………………………………………………......……… (17)*

6- The mean of the Time Growth for Design and Construction in DB Industrial Projects is equal to the mean of the DBB Industrial Projects.

μ *Time Growth for Design and Execution in Industrial DB =* ***μ*** *Time Growth for Design and Execution in Industrial DBB ....……………..…………….………..… (18)*

7- The mean of Productivity in DB *Industrial* Projects is equal to the mean of the DBB *Industrial* Projects.

μ *Productivity in DB Industrial Projects =* ***μ*** *Productivity in DBB Industrial Projects …………………………………………………………………………………….……. (19)*

8- The mean of the Cost Growth for Design and Construction in DB *Industrial* Projects is equal to the mean of the DBB *Industrial* Projects.

   μ *Cost Growth for Design and Execution in Industrial DB =* ***μ*** *Cost Growth for Design and Execution in Industrial DBB ……..……………………..…………..… (20)*

9- The mean of the Cost Growth Ratio for Variation Order Ratio in DB *Industrial* Projects is equal to the mean of the DBB *Industrial* Projects.

   μ *Cost Growth Ratio for Variation Order in Industrial DB =* ***μ*** *Cost Growth Ratio for Variation Order in Industrial DBB ………………….…………………..……… (21)*

10- The mean of the Cost per Unit in DB *Industrial* Projects is equal to the mean of the DBB *Industrial* Projects.

   μ *Cost per Unit Industrial DB =* ***μ*** *Cost per Unit in Industrial DBB ……………..…………………………………………………………………......….…… (22)*

11- The mean of the Time Growth for Design and Construction in DB Residential Projects is equal to the mean of the DBB Residential Projects.

μ *Time Growth for Design and Execution in* Residential *DB =* ***μ*** *Time Growth for Design and Execution in* Residential *DBB ......………….………………………….…. (23)*

12- The mean of Productivity in DB Residential Projects is equal to the mean of DBB Residential Projects.

μ *Productivity in DB* Residential *Projects =* ***μ*** *Productivity in DBB* Residential *Projects ……………………………………………………………………………….…… (24)*

13- The mean of the Cost Growth for Design and Construction in DB Residential Projects is equal to the mean of the DBB Residential Projects.

μ *Cost Growth for Design and Execution in* Residential *DB* = ***μ*** *Cost Growth for Design and Execution in* Residential *DBB* ………………………………….……..… *(25)*

14- The mean of the Cost Growth Ratio for Variation Order Ratio in DB Residential Projects is equal to the mean of the DBB Residential Projects.

μ *Cost Growth Ratio for Variation Order in* Residential *DB* = ***μ*** *Cost Growth Ratio for Variation Order in* Residential *DBB* ………………………………..…… *(26)*

15- The mean of the Cost per Unit in DB Residential Projects is equal to the mean of the DBB Residential Projects.

μ *Cost per Unit* Residential *DB* = ***μ*** *Cost per Unit in* Residential *DBB* ………………....……………….....……………………………………………….……… *(27)*

16- The mean of the Time Growth for Design and Construction in DB Infrastructure Projects is equal to the mean of the DBB Infrastructure Projects.

μ *Time Growth for Design and Execution in* Infrastructure *DB* = ***μ*** *Time Growth for Design and Execution in* Infrastructure *DBB* ....……………………………………..… *(28)*

17- The mean of Productivity in the DB Infrastructure Projects is equal to the mean of the DBB Infrastructure Projects.

μ *Productivity in DB* Infrastructure *Projects* = ***μ*** *Productivity in DBB* Infrastructure *Projects* ……………………………………………………………………….……… *(29)*

18- The mean of the Cost Growth for Design and Construction in DB Infrastructure Projects is equal to the mean of the DBB Infrastructure Projects.

μ *Cost Growth for Design and Execution in* Infrastructure *DB =* ***μ*** *Cost Growth for Design and Execution in* Infrastructure *DBB………………………………..…… (30)*

19- The mean of the Cost Growth Ratio for Variation Order Ratio in DB Infrastructure Projects is equal to the mean of the DBB Infrastructure Projects.

μ *Cost Growth Ratio for Variation Order in* Infrastructure *DB =* ***μ*** *Cost Growth Ratio for Variation Order in* Infrastructure *DBB ………………………………..... (31)*

20- The mean of the Cost per Unit in DB Infrastructure Projects is equal to the mean of the DBB Infrastructure Projects.

μ *Cost per Unit* Infrastructure *DB =* ***μ*** *Cost per Unit in* Infrastructure *DBB ………………….……………………………………………………………………..……… (32)*

This study will formulate the above mentioned five (5) null hypotheses and whether they are significantly lower or higher in DB projects than the DBB projects in the Eastern Province of Saudi Arabia. The test interpretation will consider the following:

1- *H0:* The variance is equal to 1.
2- *Ha:* The variance is different from 1.
3- 95% confidence interval on the variance.

If the computed *p*-value is lower than the significance level alpha=0.05, this study will reject the null hypothesis H0, and accept the alternative hypothesis Ha

Also if the mean of the DB projects is equal to that of the DBB projects, the null hypothesis will be accepted.

Levene's test was conducted to check the homogeneity of variance in DB and DBB projects.

The null hypothesis for Levene's test was that the variance of DB and DBB projects are equal. If the p-value is less than 0.05, the null hypothesis of equal variance is rejected.

T-test for unequal variances was conducted to determine the means are significantly different or not, since the variances of DB and DBB projects were not equal.

The null hypothesis for this test is that the variances of DB and DBB are equal.

Alternative Hypothesis

The hypothesis of this study is that there is a significant difference between the time and cost growth percentage between the Design-Build and Design-Bid-Build projects as a combined completed project for both government and public projects.

The primary aim of this study was to compare the performance between Design-Bid-Build and Design-Build projects in terms of time and cost for execution project industries.

The performance data for DB and DBB projects for multiple building types; Commercial, Industrial, Residential and Infrastructure required statistical analysis such as descriptive statistics, the normality test, and the ANOVA t-test for unequal variance to evaluate the performance metrics between DB and DBB projects in regards to time and cost.

4.3.1.1 – Commercial Projects

Table 05 illustrates the results indication of cost performance by mean, median and standard deviation for the Design-Build of Commercial Projects versus Design-Bid-Build Projects.

The results stated that the values of the mean, median, and standard deviation of the Design and Execution Cost Growth and Variation Order Ratio Cost and Cost per square meter for DB commercial projects (26.06%, 26.06%, and 35.01% respectively)are higher than that for DBB commercial projects (20.49%, 10.94%, and 26.76% respectively).

In addition, the table explains that the mean, median, and standard deviation values of the variation order cost ratio values for DB commercial projects (26.06%, 26.06%, and 35.01% respectively) are higher than the values for DBB projects (13.71%, 9.86%, and 17.50 respectively).

The mean, median, and standard deviation cost per square meter of DB commercial projects (8,550SR, 8,550SR, and 9,305SR respectively) is higher than for DBB projects (6,271SR, 3,833SR, and 5,535SR respectively). The results show that the cost performance of DB commercial projects is higher than that of DBB commercial projects.

#	Cost Metrics	Design-Build Projects (No.=02)			Design-Bid-Build Projects (No.=08)		
		Mean	Median	SD	Mean	Median	SD
1	Design and Execution Cost Growth (%)	26.06	26.06	35.01	20.49	10.94	26.76
2	Variation Order Cost Growth Ratio (%)	26.06	26.06	35.01	13.71	9.86	17.50
3	Unit Cost (SR/m2)	8,550	8,550	9,305	6,271	3,833	5,535

Table 05, Cost performance of DB versus to DBB Commercial Projects

Table 06 indicates the mean, median, and standard deviation of the time performance metrics for DB commercial projects versus DBB commercial projects.

The results stated that the mean, median, and standard deviation of the Design and Execution Time Growth of DB commercial projects (11.11%, 11.11%, and 7.86% respectively) is lower than that of DBB commercial projects (69.48%, 64.58%, and

30.71% respectively). These results mean that the total design and execution duration of DBB commercial projects is more than that of DB commercial projects.

The mean, median, and standard deviation of execution productivity for DB commercial projects (43.95, 43.95, and 23.95 m2/day respectively) is higher than that of DBB commercial projects (12.30, 7.88, and 15.26 m2/day respectively). These results mean that the productivity of DB commercial projects is higher than that of DBB commercial projects.

#	Time Metrics	Design-Build Projects (No.=02)			Design-Bid-Build Projects (No.=08)		
		Mean	Median	SD	Mean	Median	SD
1	Design and Execution Time Growth (%)	11.11	11.11	7.86	69.48	64.58	30.71
2	Productivity (m2/day)	43.95	43.95	23.95	12.30	7.88	15.26

Table 06, Time performance of DB Commercial projects versus to DBB Commercial Projects.

4.3.1.1.1 - Normality Test of Variance Analysis

A Normality Test will determine the performance metrics of equal variance for DB and DBB projects in terms of time and cost.

The most important assumption when conducting this test is supposing that the dependent variable will be distributed normally. This study conducts histograms and an Anderson Darling test to verify the assumption of normal distributions.

The information and data of Cost and Time Performance will not have a normal distribution in the case that the p-value is less than the significant level 0.05.

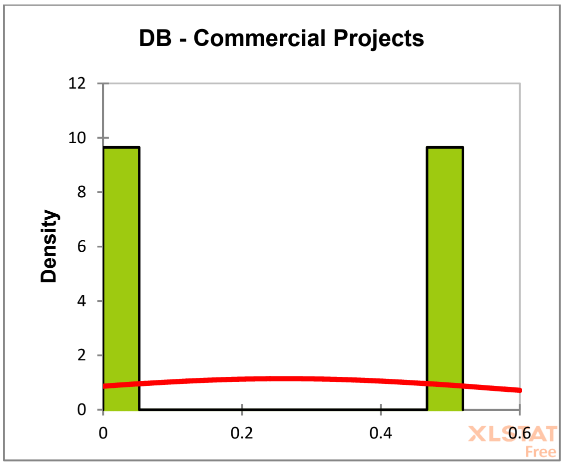
In order to get the normality distribution, a histogram was developed from the excel spreadsheet program for both cost and time performance to determine whether the cost and time performances are following the normal distributions.

The XLSTAT program was added to the excel spreadsheet program to be able to create a histogram with normal distributions.

Figure 17 shows the cost growth histograms of design and the execution for Design-Build commercial projects and Design-Bid-Build commercial projects.

The distribution of cost growth for design and execution in DBB commercial projects were normal. Meanwhile, the histograms show that the normal distribution of DBB commercial projects is higher than that of DB commercial projects.

The p-value for both DB and DBB projects is higher than 0.05 and that is the reason for the normal distribution in the graphs.



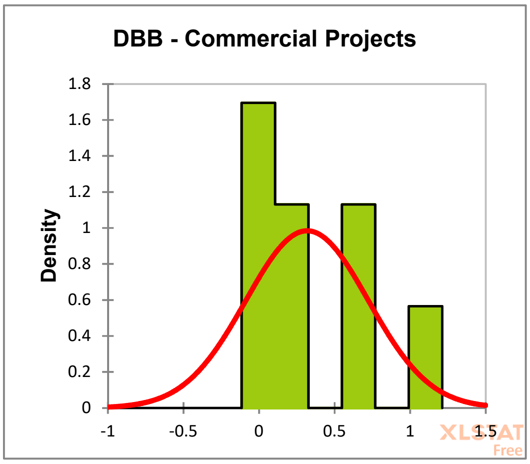


Figure 17, Histograms of Cost Growth for Design and Construction in DB versus to DBB Commercial Projects

The Anderson Darling test results are shown in Table 07, and show that the Cost growth for design and execution in DB and DBB commercial projects is normally distributed for the reason that the p-value is higher than the significant alpha level of 0.05.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05, this result is accepted.

#	Performance Cost Metrics	p-value
1	DB Design and Execution Cost Growth	0.227
2	DBB Design and Execution Cost Growth	0.170

Table 07, Design and Execution Cost Growth Anderson Darling Test of Commercial Projects.

Figure 18 shows the cost growth histograms of the Cost growth ratio for the variation order in Design-Build commercial projects and Design-Bid-Build commercial projects.

The distributions of the Cost growth ratio for the variation order in DBB commercial projects were normal. Meanwhile, the histograms show that the normal distribution of DBB commercial projects is higher than that of DB commercial projects.

The *p*-value for both DB and DBB projects is higher than 0.05 and that is the reason for normal distribution in the graphs.

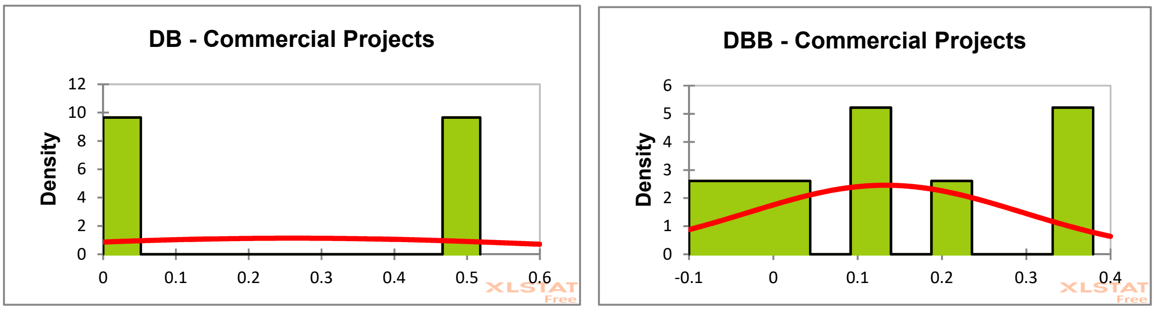


Figure 18, Histograms of Cost Growth Ratio for Variation Order in DB versus to DBB Commercial Projects

The Anderson Darling test results are shown in Table 08, and show that the Cost growth ratio for the variation order in DB and DBB commercial projects is normally distributed for the reason that the p-value is higher than the significant alpha level of 0.05.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05, this result is accepted.

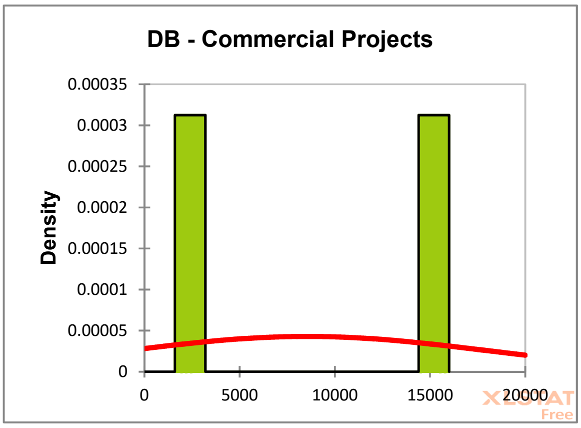
#	Performance Cost Metrics	p-value
1	DB Variation Order Cost Growth Ratio	0.227
2	DBB Variation Order Cost Growth Ratio	0.375

Table 08, Variation Order Cost Growth Ratio Anderson Darling Test of Commercial Projects.

Figure 19 shows the histograms of cost per square meter for the DB and DBB commercial projects.

The figures curve of DBB projects show a non-normal distribution and the curve is skewed to the left. Because the *p*-alpha is less than 0.05

the DB projects show a normal distribution with a slight skew to the left.



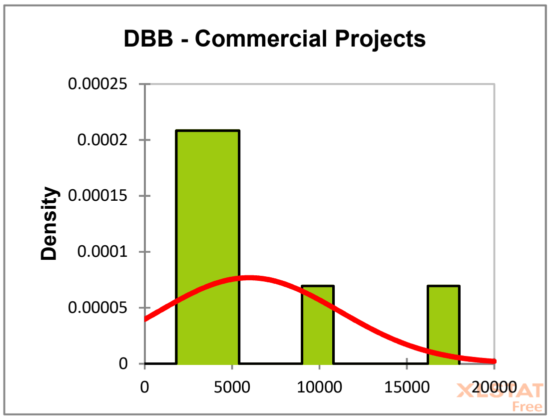


Figure 19, Histograms of Cost per Unit in DB versus to DBB Commercial Projects

The Anderson Darling test results of cost per square meter for commercial projects are shown in Table 12, and show that the DBB commercial projects are not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05, this result is rejected.

Table 09 also shows that the DB commercial projects are normally distributed for the reason that the p-value is more than the significant alpha level of 0.05.

#	Performance Cost Metrics	p-value
1	DB Cost per Square Meter	0.227
2	DBB Cost per Square Meter	0.002

Table 09, Cost per Unit Anderson Darling Test of Commercial Projects.

Figure 20 shows the time growth histograms of design and execution for Design-Build commercial projects and Design-Bid-Build commercial projects.

The distribution of time growth for design and execution in DB and DBB commercial projects were normal. Meanwhile, the histograms show that the normal distribution of DBB commercial projects is slightly skewed to the left and the normal distribution of the DB commercial projects is slightly skewed to the right.

The *p*-value for both the DB and DBB projects is higher than 0.05 and that is the reason for the normal distribution in the graphs.

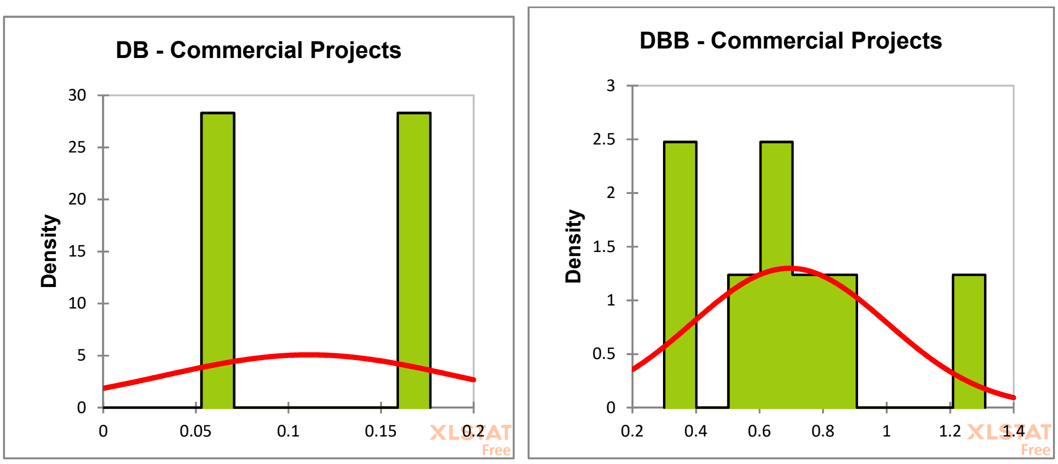


Figure 20, Histograms of Time Growth for Design and Construction in DB versus to DBB Commercial Projects

The Anderson Darling test results are shown in Table 10, and show that the Time growth for the design and execution in DB and DBB commercial projects is normally distributed for the reason that the p-value is higher than the significant alpha level of 0.05.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05, this result is accepted.

#	Performance Time Metrics	p-value
1	DB Design and Execution Time Growth	0.227
2	DBB Design and Execution Time Growth	0.525

Table 10, Anderson Darling Test of Time growth for design and execution in Commercial Projects.

Figure 21 shows the histograms of productivity (Square Meter per Day) for DB and DBB commercial projects.

The figures curve for the DBB projects show a non-normal distribution and the curve is skewed to the left because the *p*-alpha is less than 0.05.

The DB projects show a normal distribution because the *p*-alpha is higher than 0.05.

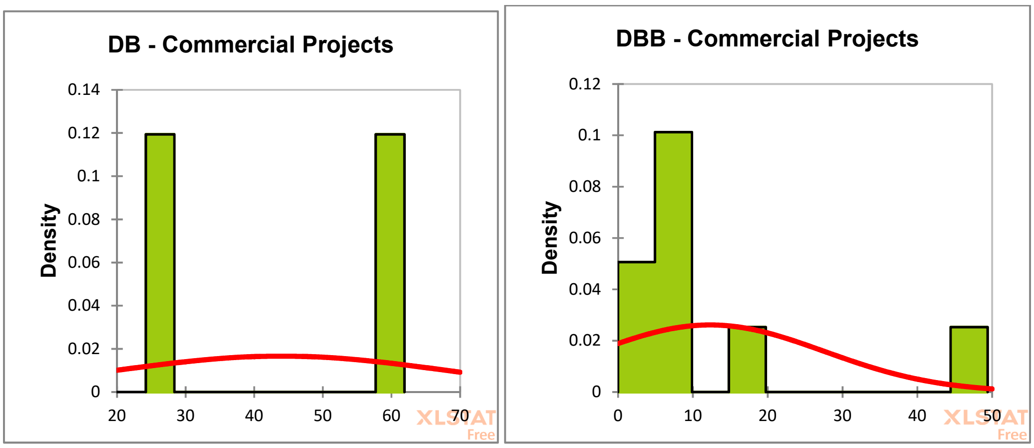


Figure 21, Histograms of Productivity in DB versus to DBB Commercial Projects

The Anderson Darling test results of productivity (Square Meter per Day) for commercial projects is shown in Table 11, and shows that the DBB commercial projects are not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level 0.05, this result is rejected. However, the results of the normality test will not be affected if the sample size is more than 30 samples. Table 11 also shows that the DB commercial projects are normally distributed for the reason that the p-value is more than the significant alpha level of 0.05.

#	Performance Productivity Metrics	p-value
1	DB Productivity (m2/day)	0.227
2	DBB Variation Order Cost Growth Ratio	0.003

Table 11, Productivity (m2/day) Anderson Darling Test of Commercial Projects.

4.3.1.1.2 - Unequal Variance Test

Table 12 shows the results of the Analysis of Variance (ANOVA) test for Cost Performance Metrics and indicates that the p-values for all cost performance metrics are more than 0.05. The null hypothesis for the mean of the cost performance metrics in DB and DBB commercial projects is accepted. Meanwhile, table 12 shows the mean of design and execution cost growth, the variation order cost growth ratio and the cost per unit of DB commercial projects (26.06%, 26.06%, and 8,550 SR/square meter, respectively) is higher than that of DBB commercial projects (31.83%, 13.30%, and 5976 SR/square meter, respectively).

#	Cost Performance Metrics	Mean		Critical Value	p-value
		DB (No.=02)	DBB (No.=08)		
1	Design and Execution Cost Growth (%)	26.06	31.83	2.31	0.859
2	Variation Order Cost Growth Ratio (%)	26.06	13.30	2.31	0.434
3	Cost per Unit (SR/m2)	8,550	5,976	2.31	0.594

Table 12, Results of T-test for unequal variance of Cost Performance Metrics for Commercial Projects.

Figure 22 shows the box plots that compare the design and execution cost growth metrics of the Design-Build versus the Design-Bid-Build commercial projects. The figure shows that there are higher outliers of Design and Execution Cost Growth Performance for DBB commercial projects than for DB commercial projects.

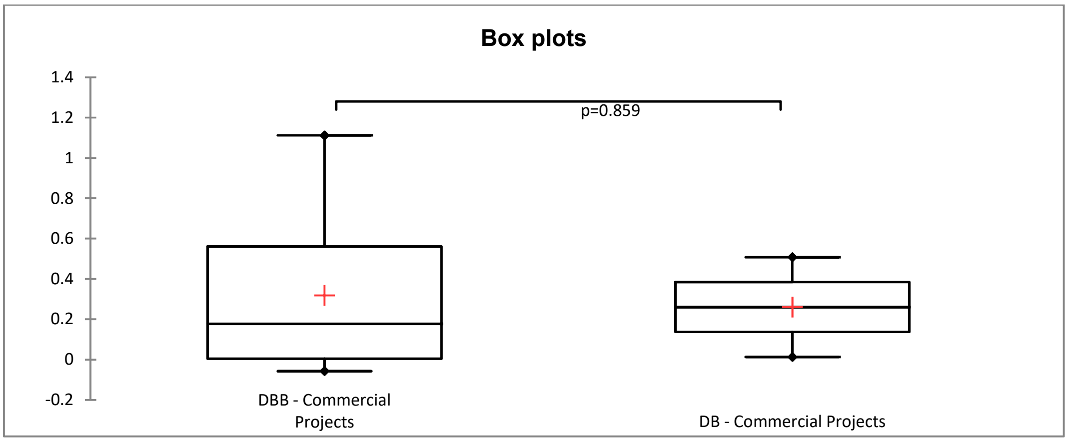


Figure 22, Commercial Projects Box Plots for Cost Growth.

Figure 23 shows the box plots that compare the variation order cost growth ratio metrics of the Design-Build versus the Design-Bid-Build commercial projects. The figure shows that there are higher outliers of Variation Order Cost Growth Ratio Performance for DB commercial projects than for DBB commercial projects.

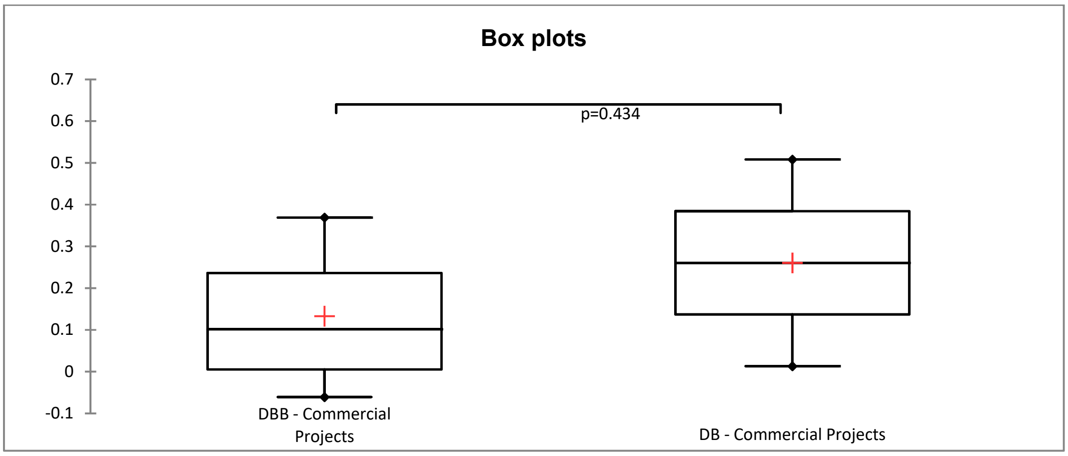


Figure 23, Variation Order Box Plots for Cost Growth Ratio in Commercial Projects.

Figure 24 shows the box plots that compare the cost per square meter metrics of Design-Build versus Design-Bid-Build commercial projects. The figure shows that there are higher outliers of Cost per Square Meter Performance for DB commercial projects than for DBB commercial projects. There are two outliers for the Cost Growth of DB commercial projects, while DBB commercial projects don't have any outliers.

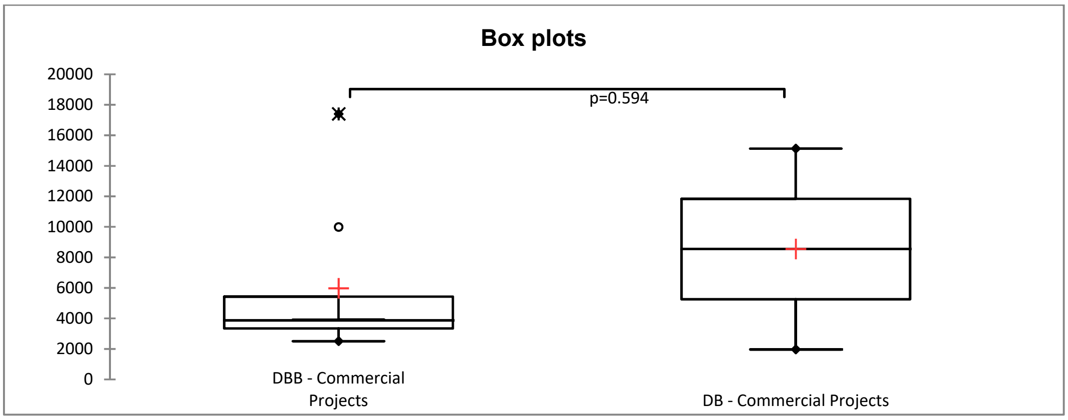


Figure 24, Box Plots of Unit Cost Performance per square meter Metrics for Commercial Projects.

Table 13 shows the results of the Analysis of Variance (ANOVA) test for Time Performance Metrics.

The mean of Design and Execution Time Growth for DBB commercial projects (69.48%) is significantly higher than the mean of DB commercial projects (11.11%) for the reason that the p-values for Design and Execution Time Growth is less than the alpha level of 0.05. However, the productivity of DB commercial projects (43.95%) is higher than that of DBB commercial projects (12.30%).

The p-value of design and execution time growth and productivity is less than the significant alpha level of 0.05, as indicated in table 16 below.

#	Time Performance Metrics	Mean DB (No.=02)	Mean DBB (No.=08)	Critical Value	p-value
1	Design and Execution Time Growth (%)	11.11	69.48	2.31	0.034
2	Productivity (m2/day)	43.95	12.30	2.31	0.042

Table 13, Results of T-test for unequal variance of Time Performance Metrics for Commercial Projects

Figure 25 shows the box plots that compare the design and execution time growth metrics of the Design-Build versus the Design-Bid-Build commercial projects. The figure shows that there are higher outliers of Design and Execution Time Growth Performance for DBB commercial projects than for DB commercial projects. There is one outlier for Time Growth of DBB commercial projects, while the DB projects don't have any outliers.

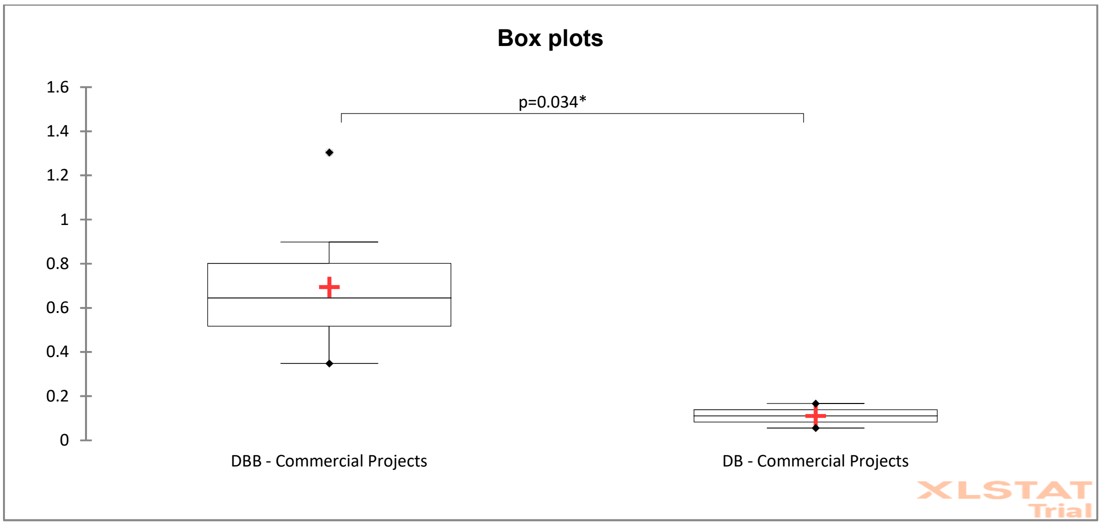


Figure 25, Commercial Projects Box Plots for Time Growth.

Figure 26 shows the box plots that compare the productivity performance metrics of Design-Build versus the Design-Bid-Build commercial projects.

The figure indicates that there are lower outliers of productivity performance for DB commercial projects than for DBB commercial projects. There are three outliers for DB commercial projects and no outliers for DBB commercial projects.

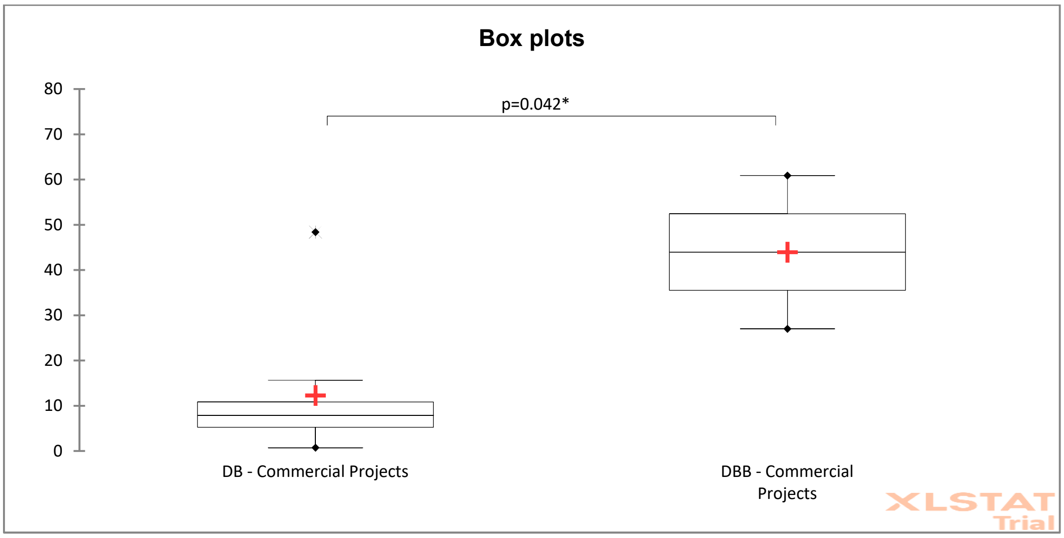


Figure 26, Box Plots of Productivity Performance Metrics for Commercial Projects.

4.3.1.2 - Industrial Projects

Table 14 illustrates the results showing the mean, median and standard deviation of the cost performance metrics for the Design-Build of Industrial Projects versus the Design-Bid-Build Projects.

The results stated that the mean and median values of Cost growth for the design and execution in DB industrial projects (20.63% and14.29% respectively) are higher than for DBB industrial projects (13.28% and 4.56% respectively). However, the standard deviation values of Cost growth for design and execution in DB industrial projects (11.00%) is lower than that for DBB industrial projects (19.58%).

In addition, the table explains that the mean, median, and standard deviation values of the variation order cost ratio values for DB industrial projects (20.63% and14.29%, respectively) are higher than that for DBB industrial projects (13.28% and 4.56%, respectively). However, the standard deviation values of Cost growth for design and execution in DB industrial projects (11.00%) is lower than that for DBB industrial projects (12.22%).

The mean and median of the cost per square meter for DB industrial projects ((9,112 SR and 727 SR) /Square Meter respectively) is lower than that for the DBB projects ((9,831 SR and 3,607 SR) /Square Meter, respectively). However, the standard deviation of Cost per Square Meter for DB industrial projects (14,843 SR is higher than that of DBB industrial projects (10,635 SR).

#	Cost Metrics	Design-Build Projects (No.=03)			Design-Bid-Build Projects (No.=09)		
		Mean	Median	SD	Mean	Median	SD
1	Design and Execution Cost Growth (%)	20.63	14.29	11.00	13.28	4.56	19.58
2	Variation Order Cost Growth Ratio (%)	20.63	14.29	11.00	9.86	4.36	12.22
3	Unit Cost (SR/m2)	9,112	727	14,843	9,831	3,607	10,635

Table 14, Cost performance metrics of DB versus to DBB Industrial Projects.

Table 15 indicates the mean, median, and standard deviation of time performance metrics for DB industrial projects versus DBB industrial projects.

The results stated that the mean, median, and standard deviation of Design and Execution Time Growth for DB industrial projects (62.04%, 75.00%, and 35.17%, respectively) is lower than that for DBB industrial projects (119.12%, 100.12%, and 66.75%, respectively). These results mean that the total design and execution duration of DBB industrial projects is more than that for DB industrial projects.

The mean, median, and standard deviation of execution productivity for DB industrial projects (17.13, 13.10, and 11.83 m2/day, respectively) is lower than that for

DBB industrial projects (20.16, 3.15, and 40.20 m2/day, respectively). These results mean that the productivity of DBB industrial projects is higher than that of DB industrial projects.

#	Time Metrics	Design-Build Projects (No.=03)			Design-Bid-Build Projects (No.=09)		
		Mean	Median	SD	Mean	Median	SD
1	Design and Execution Time Growth (%)	62.04	75.00	35.17	119.12	100.00	66.75
2	Productivity (m2/day)	17.13	13.10	11.83	20.16	3.15	40.20

Table 15, Time performance metrics of DB Industrial projects versus to DBB Industrial Projects.

4.3.1.2.1 - Normality Test of Variance Analysis

Figure 27 shows the cost growth histograms of design and execution for Design-Build and Design-Bid-Build industrial projects.

The distribution of cost growth for the design and execution in DBB industrial projects were not normally distributed. However, the distribution of cost growth for the design and execution in DB industrial projects were normally distributed.

The *p*-value of DBB industrial projects is less than 0.05 and that is the reason for the non-normal distribution in the graphs.

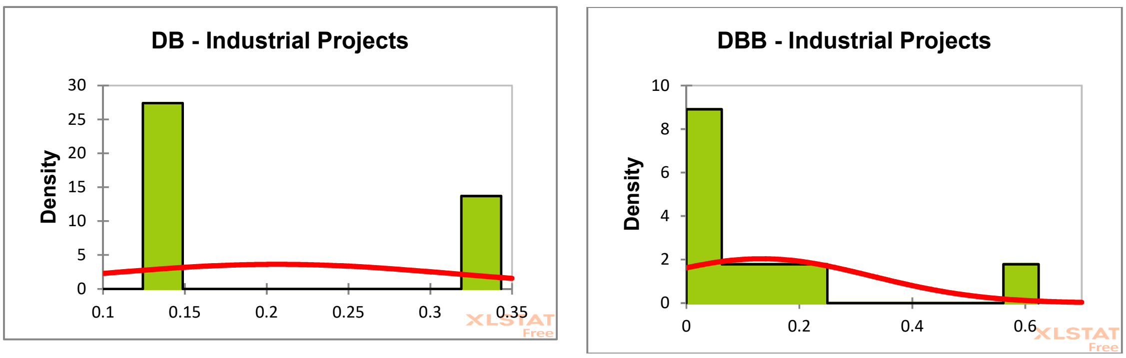


Figure 27, Histograms of Cost Growth for Design and Construction in DB versus to DBB Industrial Projects

The Anderson Darling test results are shown in Table 16 and show that the Cost growth for design and execution in DBB industrial projects is not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05 in DBB industrial projects.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05, this result is rejected.

In addition, table 19 shows that the Cost growth for design and execution in DB industrial projects is normally distributed for the reason that the p-value is a little higher than the significant alpha level of 0.05.

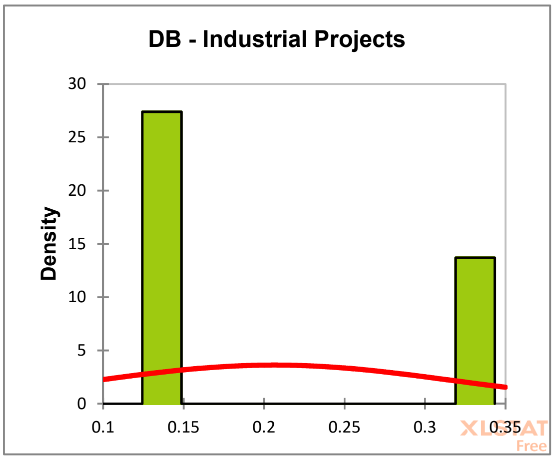
#	Performance Cost Metrics	p-value
1	DB Design and Execution Cost Growth	0.057
2	DBB Design and Execution Cost Growth	0.002

Table 16, Design and Execution Cost Growth Anderson Darling Test of Industrial Projects.

Figure 28 shows the cost growth histograms of the Cost growth ratio for the variation order in Design-Build and Design-Bid-Build industrial projects.

The distribution of cost growth for design and execution in DBB industrial projects was not normally distributed with a skew to the left. However, the distribution of cost growth for design and execution in DB industrial projects was normally distributed.

The *p*-value of DBB industrial projects is less than 0.05 and that is the reason for the non-normal distribution in the graphs.



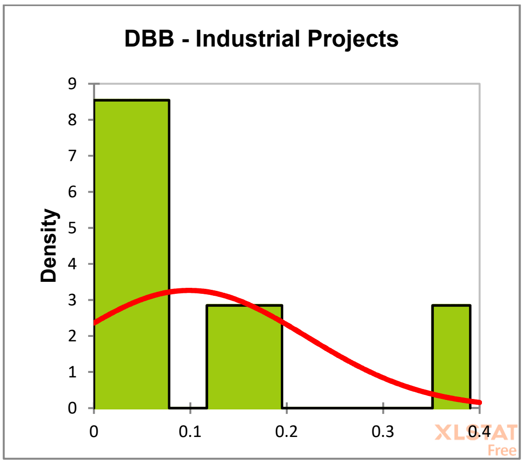


Figure 28, Histograms of Cost Growth Ratio for Variation Order in DB versus to DBB Industrial Projects

The Anderson Darling test results are shown in Table 17 and this shows that the variation order cost growth ratio of DBB industrial projects is not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05 in DBB industrial projects.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05 this result is rejected.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05 this result is rejected.

In addition, table 17 shows that the Cost growth for design and execution in DB industrial projects is normally distributed for the reason that the p-value is a little higher than the significant alpha level of 0.05.

#	Performance Cost Metrics	p-value
1	DB Variation Order Cost Growth Ratio	0.057
2	DBB Variation Order Cost Growth Ratio	0.015

Table 17, Variation Order Cost Growth Ratio Anderson Darling Test of Industrial Projects.

Figure 29 shows the cost per square meter histograms for Design-Build and Design-Bid-Build industrial projects.

The distribution of cost growth for design and execution in DBB industrial projects was not normally distributed with a skew to the left. However, the distribution of cost growth for design and execution in DB industrial projects was normally distributed.

The *p*-value of DBB industrial projects is less than 0.05 and that is the reason for non-normal distribution in the graphs.

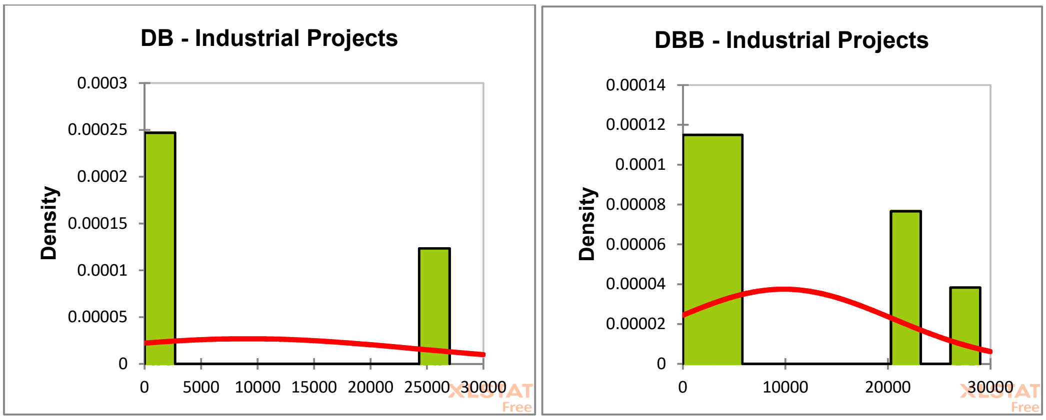


Figure 29, Histograms of Cost per Unit in DB versus to DBB Industrial Projects

The Anderson Darling test results of cost per square meter for industrial projects are shown in Table 18. They show that the DBB industrial projects are not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05.

The null hypothesis assumes that the data will not be normally distributed. If the p-value is less than the significant alpha level of 0.05 this result is rejected.

Table 18 also shows that the DB industrial projects are normally distributed for the reason that the p-value is more than the significant alpha level of 0.05.

#	Performance Cost Metrics	p-value
1	DB Cost per Square Meter	0.063
2	DBB Cost per Square Meter	0.008

Table 18, Cost per Unit Anderson Darling Test of Industrial Projects.

Figure 30 shows the time growth histograms of design and execution for Design-Build industrial projects and Design-Bid-Build industrial projects.

The distribution of time growth for design and execution in DB and DBB industrial projects was normal. Meanwhile, the histograms show that the normal distribution of DBB industrial projects is a little skewed to the left and the normal distribution of DB industrial projects is a little skewed to the right.

The *p*-value for both DB and DBB projects is higher than 0.05 and that is the reason for normal distribution in the graphs.

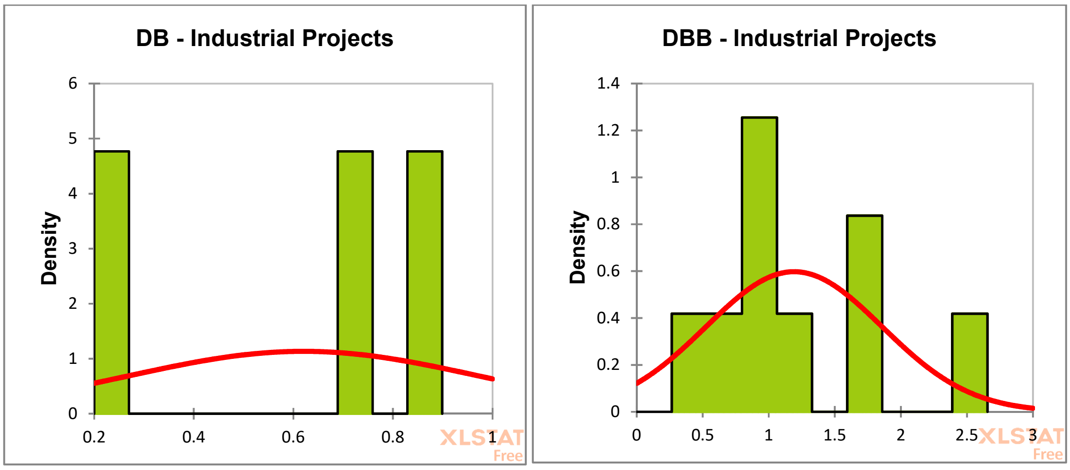


Figure 30, Histograms of Time Growth for Design and Construction in DB versus to DBB Industrial Projects.

The Anderson Darling test results are shown in Table 19. They show that the Time growth for design and execution in both DB and DBB industrial projects is normally distributed for the reason that the p-values are higher than the significant alpha level of 0.05.

The null hypothesis assumes that the data will be normally distributed if the p-value is more than the significant alpha level of 0.05.

#	Performance Time Metrics	p-value
1	DB Design and Execution Time Growth	0.263
2	DBB Design and Execution Time Growth	0.506

Table 19, Design and Execution Time Growth Anderson Darling Test of Industrial Projects.

Figure 31 shows the histograms of time growth for design and execution in DB and DBB industrial projects.

The figures curve of DBB projects show a non-normal distribution and the curve was skewed to the left because the *p*-alpha is less than 0.05.

The DB projects show a normal distribution because the *p*-alpha is higher than 0.05.

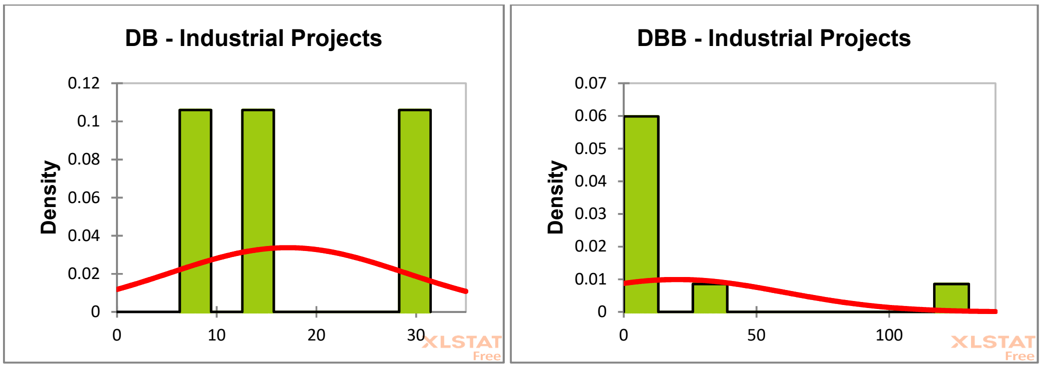


Figure 31, Histograms of Productivity in DB versus to DBB Industrial Projects

The Anderson Darling test results of productivity (Square Meter per Day) for industrial projects are shown in Table 20. They indicate that the DBB industrial projects are not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05 this result is rejected.

In addition, the DB industrial projects are normally distributed for the reason that the p-value is more than the significant alpha level of 0.05.

#	Performance Productivity Metrics	p-value
1	DB Productivity (m2/day)	0.303
2	DBB Variation Order Cost Growth Ratio	< 0.0001

Table 20, Productivity (m2/day) Anderson Darling Test of Industrial Projects.

4.3.1.2.2 - Unequal Variance Test

Table 21 shows the results of the Analysis of Variance (ANOVA) test for the Cost Performance Metrics and indicates that the p-values for all cost performance metrics are more than 0.05. The null hypothesis for the mean of the cost performance metrics in DB and DBB industrial projects is accepted. Meanwhile, table 21 shows that the mean of design and execution cost growth, the variation order cost growth ratio for DB industrial projects (20.63% and 13.28%, respectively) is higher than that for DBB industrial projects (13.28% and 9.86%, respectively). However, the cost per unit for DB industrial projects (9,112 SR/m2) is lower than that for DBB projects (9,831 SR/m2).

#	Cost Performance Metrics	Mean		Critical Value	p-value
		DB (No.=03)	DBB (No.=09)		
1	Design and Execution Cost Growth (%)	20.63	13.28	2.23	0.558
2	Variation Order Cost Growth Ratio (%)	20.63	9.86	2.23	0.207
3	Cost per Unit (SR/m2)	9,112	9,831	2.23	0.928

Table 21, Results of T-test for unequal variance of Cost Performance Metrics for Industrial Projects.

Figure 32 shows the box plots that compare the design and execution cost growth metrics of Design-Build versus Design-Bid-Build industrial projects. The figure shows that there are higher outliers of Design and Execution Cost Growth Performance for DB industrial projects than for DBB industrial projects. However, there is one outlier for the Cost Growth of DBB industrial projects, while DB industrial projects don't have any outliers.

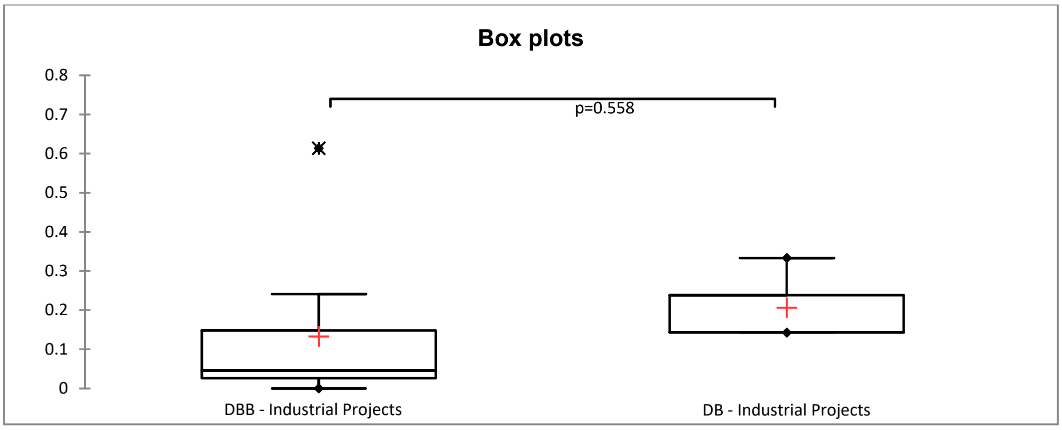


Figure 32, Industrial Projects Box Plots for Cost Growth.

Figure 33 shows the box plots that compare the variation order cost growth ratio metrics of Design-Build versus Design-Bid-Build industrial projects and shows that there are higher outliers of Variation Order Cost Growth Ratio Performance for DB industrial projects than for DBB industrial projects. Meanwhile, there is one outlier for the Cost Growth of DBB industrial projects, while DB industrial projects don't have any outliers.

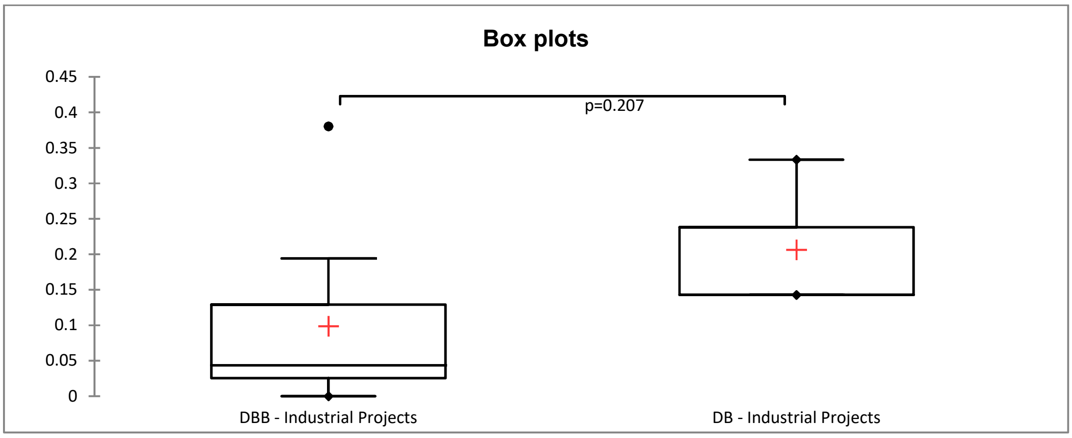


Figure 33, Variation Order Box Plots for Cost Growth Ratio in Industrial Projects.

Figure 34 shows the box plots that compare the cost per square meter metrics of Design-Build versus Design-Bid-Build industrial projects and shows that there are higher outliers of Cost per Square Meter Performance for DBB industrial projects than for DB industrial projects.

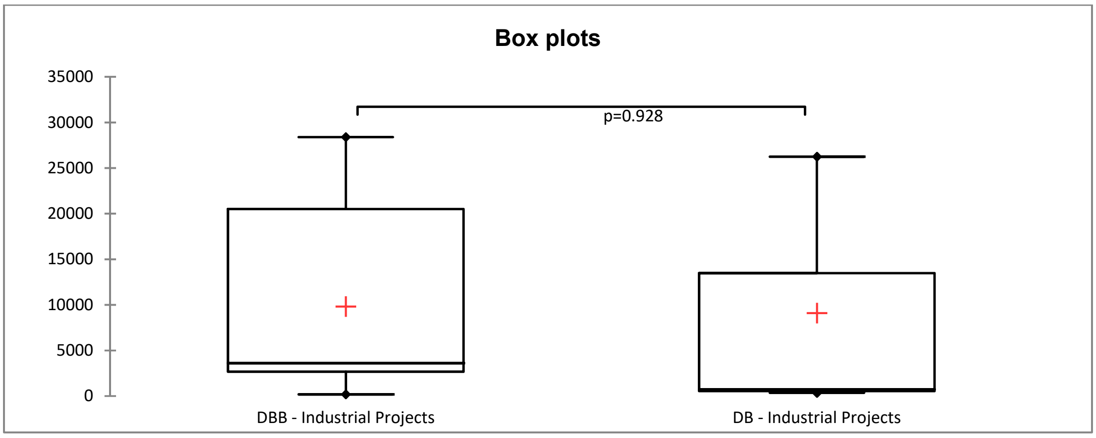


Figure 34, Box Plots of Unit Cost Performance per square meter Metrics for Industrial Projects.

Table 22 shows the results of Analysis of the Variance (ANOVA) test for Time Performance Metrics.

The mean of Design and Execution Time Growth and Productivity (Square Meter per Day) for DBB industrial projects (119.12% and 20.16%, respectively) are higher than the mean of the DB industrial projects (62.04% and 17.13%, respectively). Meanwhile, there are no significant differences between the DB and DBB industrial projects. Because the p-value of design and execution time growth and productivity is more than the significant alpha level of 0.05.

#	Time Performance Metrics	Mean		Critical Value	p-value
		DB (No.=03)	DBB (No.=09)		
1	Design and Execution Time Growth (%)	62.04	119.12	2.23	0.196
2	Productivity (m2/day)	17.13	20.16	2.23	0.903

Table 22, Results of T-test for unequal variance of Time Performance Metrics for Industrial Projects.

Figure 35 shows the box plots that compare the design and execution time growth metrics for Design-Build versus Design-Bid-Build industrial projects. The figure shows that there are higher outliers of Design and Execution Time Growth Performance for DBB industrial projects than for DB industrial projects.

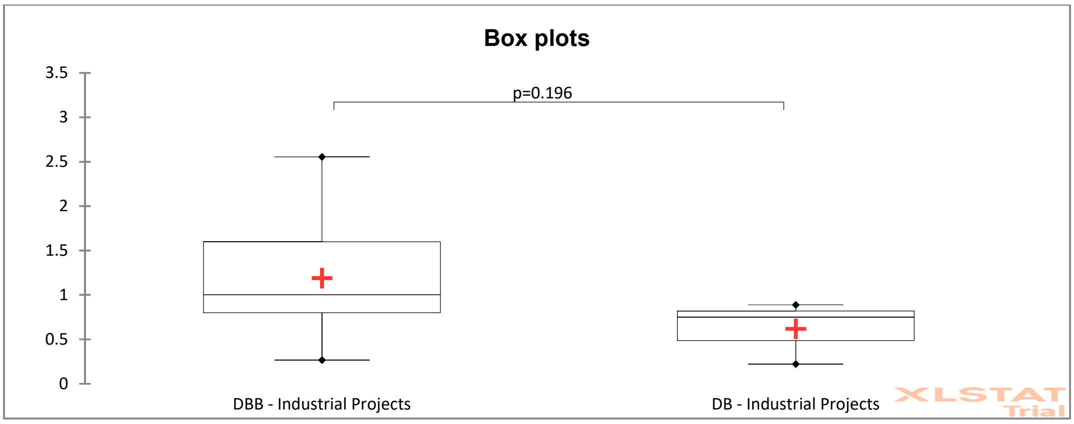


Figure 35, Industrial Projects Box Plots for Time Growth.

Figure 36 shows the box plots that compare the productivity performance metrics of Design-Build versus Design-Bid-Build industrial projects.

The figure indicates that there are lower outliers of productivity performance for DBB industrial projects than DBB industrial projects. Meanwhile, there are two outliers for DBB industrial projects and no outliers for DB industrial projects.

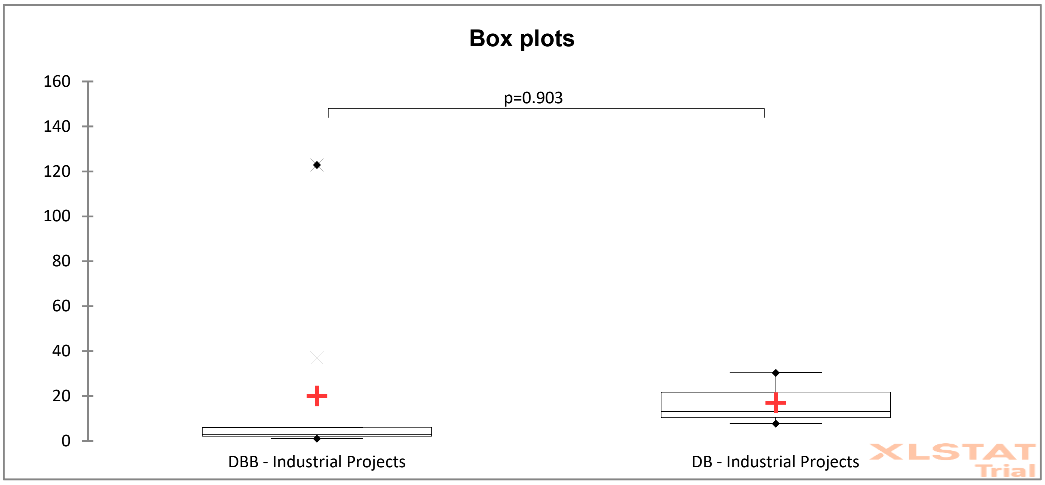


Figure 36, Box Plots of Productivity Performance Metrics for Industrial Projects.

4.3.1.3 - Residential Projects

Table 23 illustrates the results indication for the mean, median and standard deviation of the cost performance metrics for the Design-Build of Residential Projects versus Design-Bid-Build Projects.

The results stated that the mean, median, and standard deviation values of Cost growth for the design and execution in DB residential projects (0.00%, 0.00%, and 0.00%, respectively) are higher than those for DBB residential projects (4.24 %, 3.21%, and 3.61%, respectively).

In addition, the table explains that the mean, median, and standard deviation values of Cost growth ratio for variation order in DB residential projects (0.00%, 0.00%, and 0.00%, respectively) are higher than for DBB residential projects (3.97 %, 3.11%, and 3.15%, respectively).

Furthermore, the mean, median, and standard deviation of cost per square meter for DB residential projects (1,333 SR) is lower than the DBB projects (3,686 SR, 3,074 SR, and 1,533 SR, respectively).

The results mean that the cost performance for DB residential projects is lower than for DBB residential projects.

#	Cost Metrics	Design-Build Projects (No.=01)			Design-Bid-Build Projects (No.=11)		
		Mean	Median	SD	Mean	Median	SD
1	Design and Execution Cost Growth (%)	0.00	0.00	0.00	4.24	3.21	3.61
2	Variation Order Cost Growth Ratio (%)	0.00	0.00	0.00	3.97	3.11	3.15
3	Unit Cost (SR/m2)	1,333	1,333	1,333	3,686	3,074	1,533

Table 23, Cost performance metrics of DB versus to DBB Residential Projects.

Table 24 indicates the mean, median, and standard deviation of time performance metrics for DB residential projects versus DBB residential projects.

The results stated that the mean, median, and standard deviation of Design and Execution Time Growth of DB residential projects (0.00%, 0.00%, and 0.00%, respectively) is lower than for DBB residential projects (57.73%, 40.00%, and 41.12%, respectively). These results mean that the total design and execution duration of DBB residential projects is more than for DB residential projects.

The mean, median, and standard deviation of execution productivity (Square Meter per Day) for DB residential projects (50.00, 50.00, and 50.00 m2/day, respectively) is lower than for DBB residential projects (21.24, 5.45, and 40.67, respectively). These results mean that the productivity of DBB residential projects was lower than for DB residential projects.

The mean, median, and standard deviation of productivity for DB residential project is 50.00 due to there being one project only.

#	Time Metrics	Design-Build Projects (No.=01)			Design-Bid-Build Projects (No.=11)		
		Mean	Median	SD	Mean	Median	SD
1	Design and Execution Time Growth (%)	0.00	0.00	0.00	57.73	40.00	41.12
2	Productivity (m2/day)	50.00	50.00	50.00	21.24	5.45	40.67

Table 24, Time performance metrics of DB Residential projects versus to DBB Residential Projects.

4.3.1.3.1 - Normality Test of Variance Analysis

Figure 37 shows the cost growth histograms of design and execution for Design-Bid-Build residential projects and that there is no histogram for Design-Build residential projects due to there being one project only.

The distribution of cost growth for design and execution in DBB residential projects was not normally distributed. However, the distribution of cost growth for design and execution in DB residential projects was normally distributed with a skew to the left.

The *p*-value of DBB residential projects is less than 0.05 and that is the reason for the non-normal distribution in the graphs.

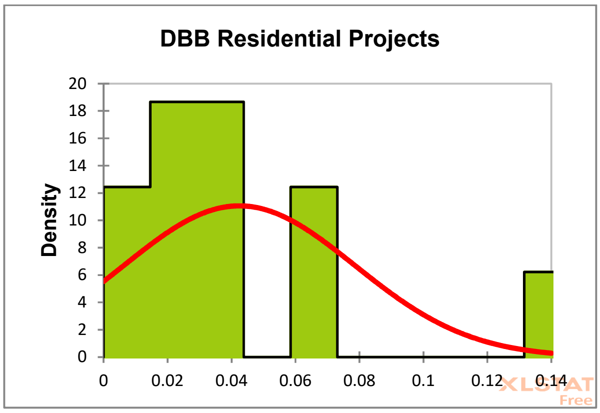


Figure 37, Histograms of Cost Growth for Design and Construction in DB versus to DBB Residential Projects.

The Anderson Darling test results are shown in Table 25. They show that the Cost growth for design and execution in DBB residential projects is not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05 in DBB residential projects.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05 this result is rejected.

#	Performance Cost Metrics	p-value
1	DB Design and Execution Cost Growth	N/A
2	DBB Design and Execution Cost Growth	0.016

Table 25, Design and Execution Cost Growth Anderson Darling Test of Residential Projects.

Figure 38 shows the cost growth histograms of Cost growth ratio for variation order in Design-Bid-Build residential projects.

The distribution of cost growth for design and execution in DBB residential projects was not normally distributed with a skew to the left.

The *p*-value for DBB residential projects is less than 0.05 and that is the reason for the non-normal distribution in the graphs.

There is not a histogram for Design-Build residential projects due to there being one project only.

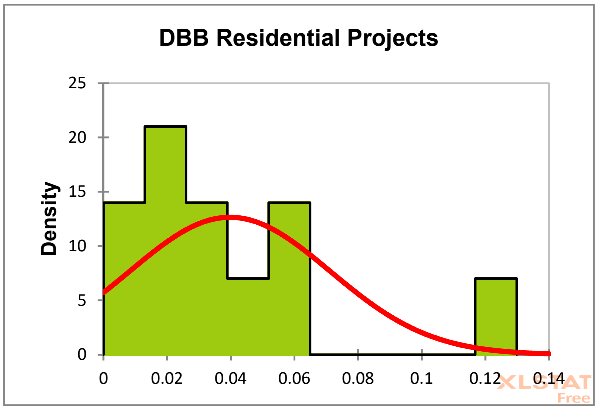


Figure 38, Histograms of Cost Growth Ration for Variation Order in DBB Residential Projects

The Anderson Darling test results are shown in Table 26. They show that the variation order cost growth ratio of DBB residential projects is not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05 in DBB residential projects.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05 this result is rejected.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05 this results is rejected.

#	Performance Cost Metrics	p-value
1	DB Variation Order Cost Growth Ratio	N/A
2	DBB Variation Order Cost Growth Ratio	0.030

Table 26, Variation Order Cost Growth Ratio Anderson Darling Test of Residential Projects.

Figure 39 shows the cost per square meter histograms for Design-Bid-Build residential projects.

The distribution of cost growth for design and execution in DBB residential projects was not normally distributed with a skew to the left. However, the distribution of cost growth for design and execution in DB residential projects was normally distributed.

The *p*-value of DBB residential projects is less than 0.05 and that is the reason for the non-normal distribution in the graphs.

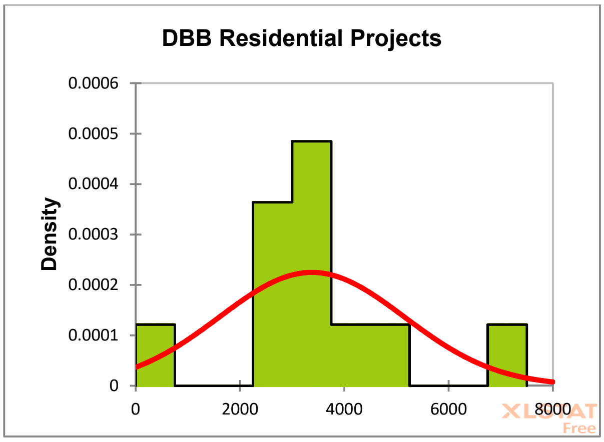


Figure 39, Histograms of Cost per Unit in DBB Residential Projects

The Anderson Darling test results of cost per square meter for residential projects are shown in Table 27. They show that the DBB residential projects are not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05.

The null hypothesis assumes that the data will not be normally distributed. If the p-value is less than the significant alpha level of 0.05 this result is rejected.

#	Performance Cost Metrics	p-value
1	DB Cost per Square Meter	N/A
2	DBB Cost per Square Meter	0.043

Table 27, Cost per Unit Anderson Darling Test of Residential Projects.

Figure 40 shows the time growth histograms of design and execution for Design-Bid-Build residential projects.

The distribution of time growth for design and execution in DBB residential projects was not normally distributed with a skew to the left.

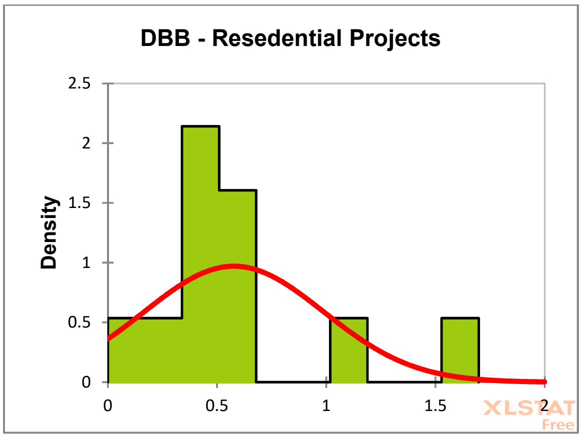


Figure 40, Histograms of Time Growth for Design and Construction in DBB Residential Projects

The Anderson Darling test results are shown in Table 28. They show that the Time growth for design and execution in both DB and DBB residential projects is normally distributed for the reason that the p-values are higher than the significant alpha level of 0.05.

The null hypothesis assumes that the data will be normally distributed, if the p-value is more than the significant alpha level of 0.05.

#	Performance Time Metrics	p-value
1	DB Design and Execution Time Growth	N/A
2	DBB Design and Execution Time Growth	0.009

Table 28, Design and Execution Time Growth Anderson Darling Test of Residential Projects.

Figure 41 shows the histograms of time growth for design and execution in DBB residential projects.

The figures curve of DBB projects shows a non-normal distribution and the curve is skewed to the left because the *p*-alpha is less than 0.05.

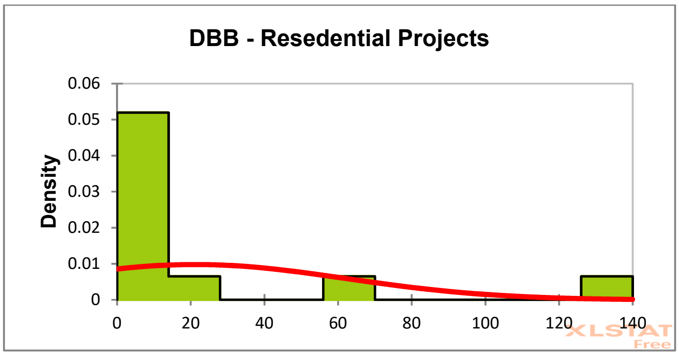


Figure 41, Histograms of Productivity for DBB Residential Projects.

The Anderson Darling test results of productivity (Square Meter per Day) for residential projects are shown in Table 29. They indicate that the DBB residential projects are not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05 this result is rejected.

#	Performance Productivity Metrics	p-value
1	DB Productivity (m2/day)	N/A
2	DBB Variation Order Cost Growth Ratio	< 0.0001

Table 29, Productivity (m2/day) Anderson Darling Test of Residential Projects.

4.3.1.3.2 - Unequal Variance Test

Table 30 shows the results of the Analysis of Variance (ANOVA) test for Cost Performance Metrics and indicates that the p-values for all cost performance metrics are more than 0.05. The null hypothesis for the mean of cost performance metrics in DB and

DBB residential projects is accepted. However, table 30 shows the mean of design and execution cost growth, variation order cost growth ratio of DB residential projects (0.00%, 0.00%, and 1,333 SR, respectively) is lower than the DBB residential projects (4.27%, 3.97%, and 3,380 SR, respectively).

#	Cost Performance Metrics	Mean		Critical Value	p-value
		DB (No.=01)	DBB (No.=11)		
1	Design and Execution Cost Growth (%)	0.00	4.24	2.20	0.137
2	Variation Order Cost Growth Ratio (%)	0.00	3.97	2.20	0.114
3	Cost per Unit (SR/m2)	1,333	3,380	2.20	0.064

Table 30, Results of T-test for unequal variance of Cost Performance Metrics for Residential Projects.

Figure 42 shows the box plots that compare the design and execution cost growth metrics of the Design-Build versus the Design-Bid-Build residential projects. The figure shows that there are higher outliers of Design and Execution Cost Growth Performance for DBB residential projects than for DB residential projects. Meanwhile, there is one higher outlier for the Cost Growth of DBB residential projects.

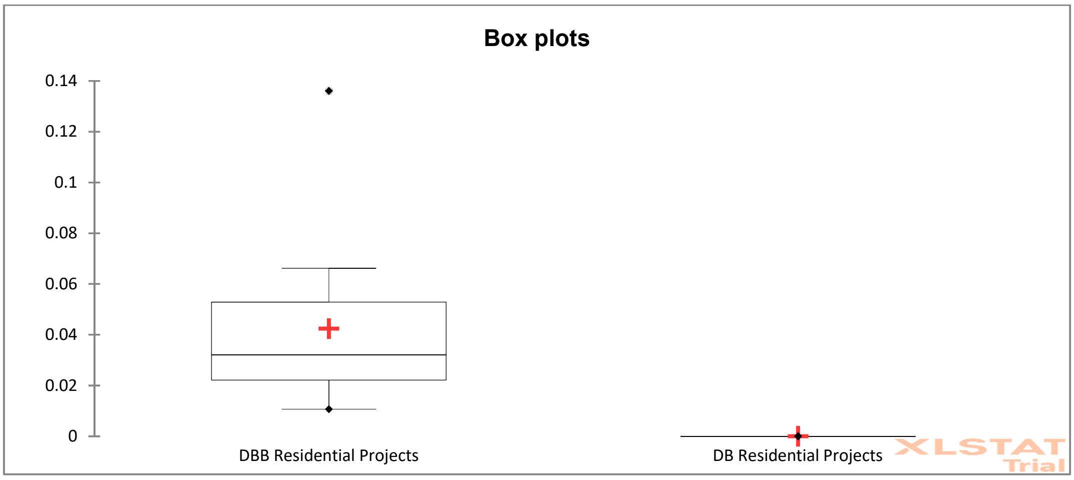


Figure 42, Residential Projects Box Plots for Cost Growth.

Figure 43 shows the box plots that compare the variation order cost growth ratio metrics of Design-Build versus Design-Bid-Build residential projects and shows that there are higher outliers of Variation Order Cost Growth Ratio Performance for DBB residential projects than for DB residential projects. Meanwhile, there is one higher outlier for the Cost Growth of DBB residential projects.

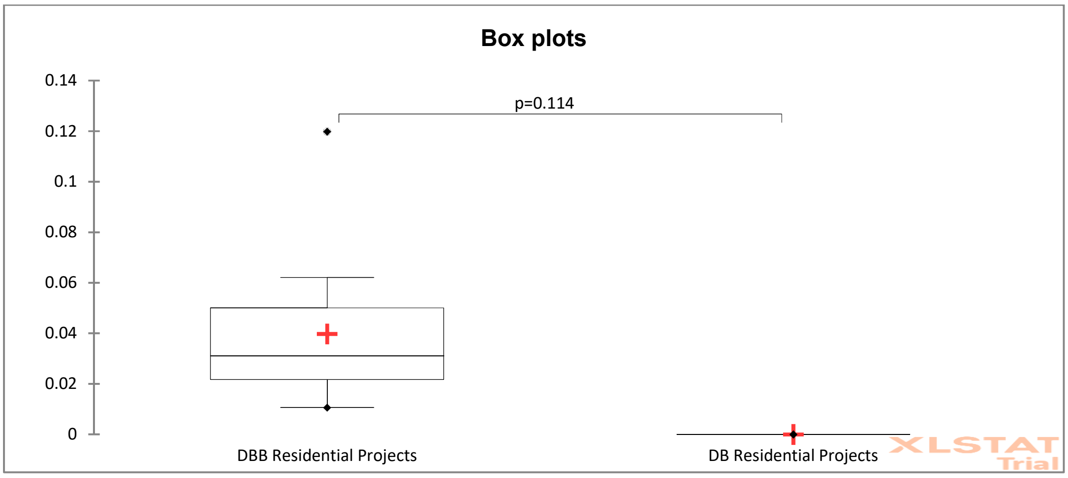


Figure 43, Box Plots of Variation Order Cost Ratio of Performance Metrics for Residential Projects.

Figure 44 shows the box plots that compare the cost per square meter metrics of Design-Build versus Design-Bid-Build residential projects and shows that there are higher outliers of Cost per Square Meter Performance for DBB residential projects than for DB residential projects. Meanwhile, there is one higher outlier and one lower outlier for the Cost Growth of DBB residential projects.

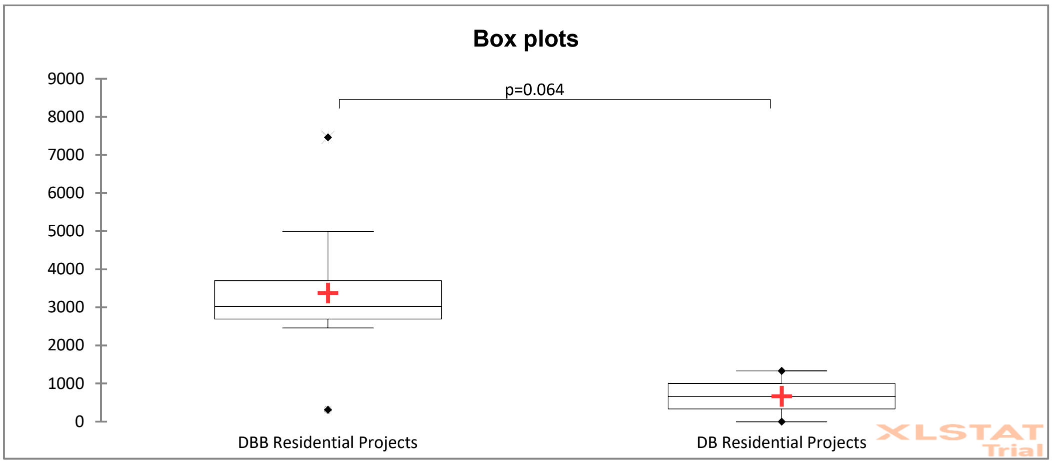


Figure 44, Box Plots of Unit Cost Performance per square meter Metrics for Residential Projects.

Table 31 shows the results of the Analysis of Variance (ANOVA) test for Time Performance Metrics.

The p-values for both design and execution time growth and productivity are more than the significant alpha level of 0.05. These results mean that there is no significant difference between DBB and DB residential projects. However, the mean of Design and Execution Time Growth of DBB residential projects (57.73%) is significantly higher than the mean of DB residential projects (0.00%). However, the mean of Productivity (Square Meter per Day) in DBB residential projects (21.24) is lower than that of DB residential projects.

#	Time Performance Metrics	Mean DB (No.=01)	Mean DBB (No.=11)	Critical Value	p-value
1	Design and Execution Time Growth (%)	0.00	57.73	2.20	0.082
2	Productivity (m2/day)	50.00	21.24	2.20	0.906

Table 31, Results of T-test for unequal variance of Time Performance Metrics for Residential Projects.

Figure 45 shows the box plots that compare the design and execution time growth metrics of Design-Build versus Design-Bid-Build residential projects. The figure shows that there are higher outliers of Design and Execution Time Growth Performance for DBB residential projects than for DB residential projects. Meanwhile, there are two higher outliers for DBB residential projects.

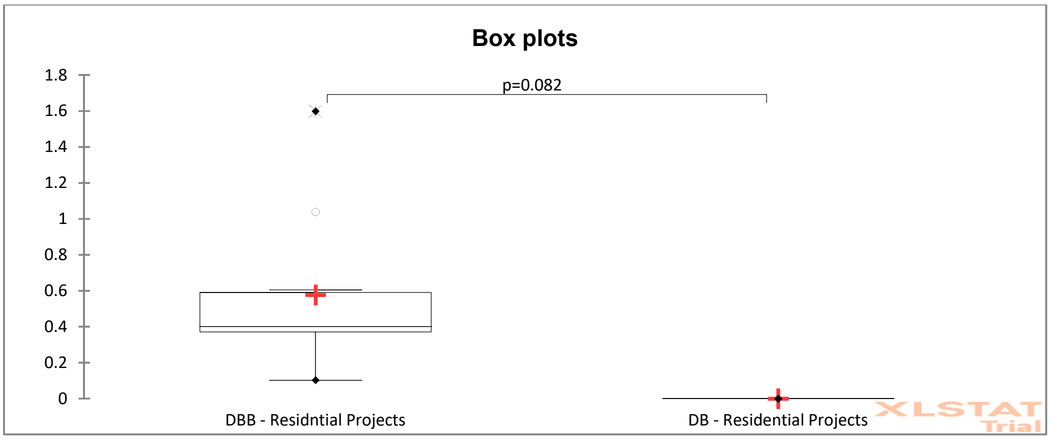


Figure 45, Residential Projects Box Plots for Time Growth.

Figure 46 shows the box plots that compare the design and execution time growth metrics of Design-Build versus Design-Bid-Build residential projects. The figure shows that there are higher outliers of Design and Execution Time Growth Performance for DB residential projects than for DBB residential projects. However, there are two higher outliers for DBB residential projects.

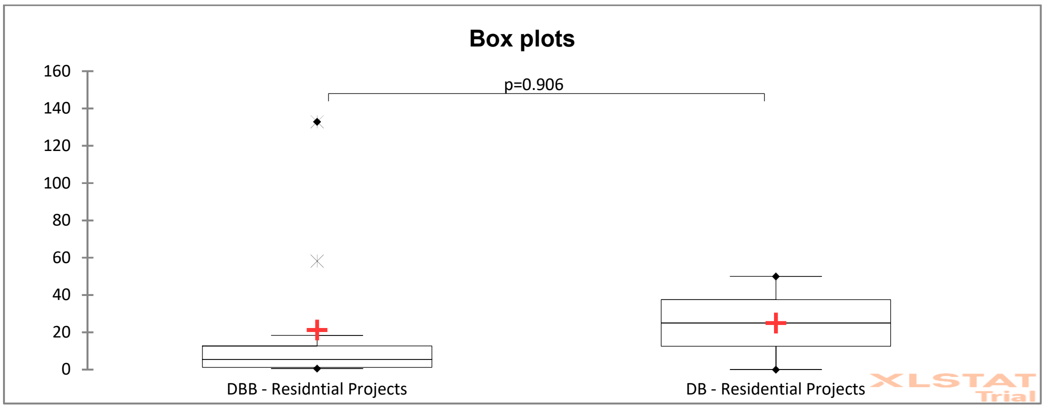


Figure 46, Box Plots of Productivity Performance Metrics for Residential Projects.

4.3.1.4 - Institutional Projects

Table 32 illustrates the results for the mean, median and standard deviation of the cost performance metrics for the Design-Build-Build of Institutional Projects.

The results stated that the mean, median, and standard deviation values of Cost growth for design and execution in DB institutional projects are 0.67%, 3.97%, and 6.10%, respectively.

In addition, the table explains that the mean, median, and standard deviation values of Cost growth ratio for variation order in DBB institutional projects are 0.32%, 3.82%, and 6.30%, respectively.

The mean, median, and standard deviation of cost per square meter for DBB institutional projects are 4,236 SR, 3,869 SR, and 940 SR, respectively.

#	Cost Metrics	Design-Bid-Build Projects (No.=11)		
		Mean	Median	SD
1	Design and Execution Cost Growth (%)	0.67	3.97	6.10
2	Variation Order Cost Growth Ratio (%)	0.32	3.82	6.30
3	Unit Cost (SR/m2)	4,236	3,869	940

Table 32, Cost performance metrics of DBB Institutional Projects

Table 33 indicates the mean, median, and standard deviation of time performance metrics for DBB institutional projects.

The results stated that the mean, median, and standard deviation of Design and Execution Time Growth for DBB institutional projects are 68.13%, 52.08%, and 54.21%, respectively.

In addition, the mean, median, and standard deviation of execution productivity (Square Meter per Day) for DBB institutional projects are 4.41, 5.17, and 1.80, respectively.

	Time Metrics	Design-Bid-Build Projects (No.=11)		
		Mean	Median	SD
1	Design and Execution Time Growth (%)	68.13	52.08	54.21
2	Productivity (m2/day)	4.41	5.17	1.80

Table 33, Time performance metrics of DBB Institutional Projects.

4.3.1.4.1 - Normality Test of Variance Analysis

Figure 47 shows the cost growth histograms of design and execution for Design-Bid-Build institutional projects.

The distribution of cost growth for design and execution in DBB institutional projects is normally distributed with a skew to the right.

The *p*-value of DBB institutional projects is more than 0.05 and that is the reason for normal distribution in the graphs.

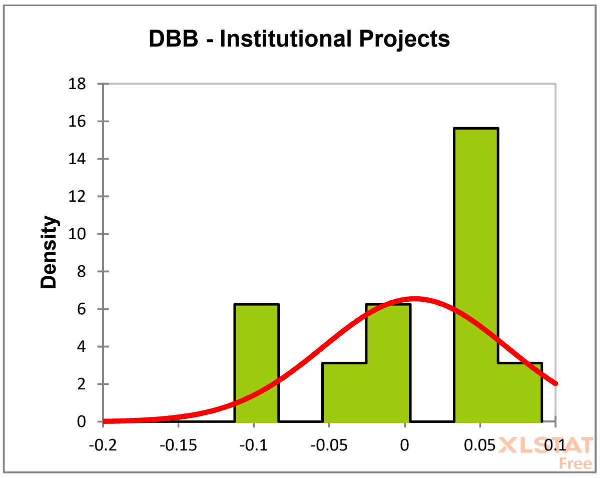


Figure 47, Histograms Cost Growth for Design and Construction DBB Institutional Projects.

The Anderson Darling test results are shown in Table 34. They show that the Cost growth for design and execution in DBB institutional projects is normally distributed for the reason that the p-value is more than the significant alpha level of 0.05. However, the histogram shows a skew to the right.

The null hypothesis assumes that the data will be normally distributed if the p-value is more than the significant alpha level of 0.05.

#	Performance Cost Metrics	p-value
1	DBB Design and Execution Cost Growth	0.126

Table 34, Design and Execution Cost Growth Anderson Darling Test of Institutional Projects.

Figure 48 shows the cost growth histograms of the variation order for Design-Bid-Build institutional projects.

The distribution of cost growth for design and execution in DBB institutional projects is normally distributed with a skew to the right.

The *p*-value of DBB institutional projects is more than 0.05 and that is the reason for the normal distribution in the graphs.

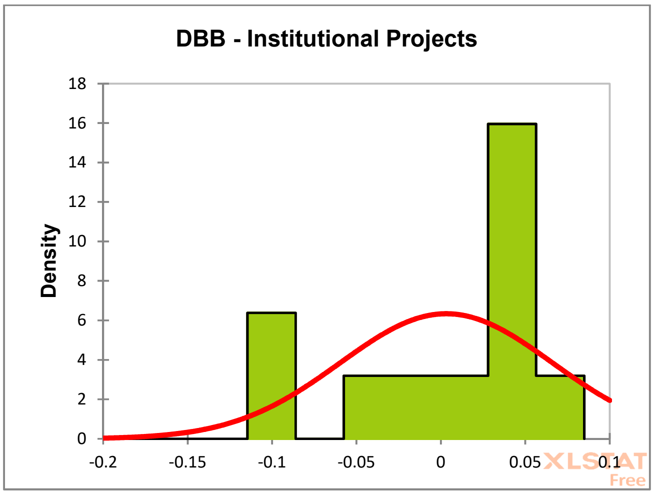


Figure 48, Histograms Cost Growth Ratio for Variation Order in DBB Institutional Projects.

The Anderson Darling test results are shown in Table 35 and show that the Cost growth for design and execution in DBB institutional projects is normally distributed for the reason that p-value is more than the significant at alpha level 0.05. However, the histogram shows a skew to the right.

The null hypothesis assumes that the data will be normally distributed, if the p-value is more than the significant alpha level of 0.05.

#	Performance Cost Metrics	p-value
1	DBB Variation Order Cost Growth Ratio	0.082

Table 35, Variation Order Cost Growth Ratio Anderson Darling Test of Institutional Projects.

Figure 49 shows the cost per square meter histograms for Design-Bid-Build institutional projects.

The distribution of cost growth for design and execution in DBB institutional projects is not normally distributed with a skew to the left.

The *p*-value of DBB institutional projects is less than 0.05 and that is the reason for the non-normal distribution in the graphs.

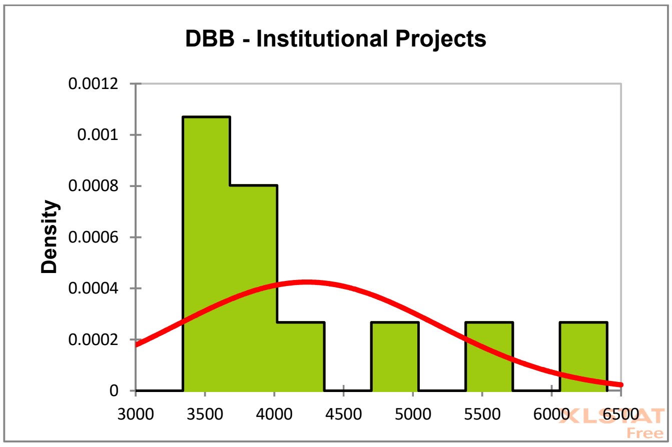


Figure 49 Histograms of cost per unit (SR/m2) in DBB Institutional Projects.

The Anderson Darling test results of cost per square meter for institutional projects are shown in Table 36 and show that the DBB institutional projects are not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05.

The null hypothesis assumes that the data will not be normally distributed. If the p-value is less than the significant alpha level of 0.05 this result is rejected.

#	Performance Cost Metrics	p-value
1	DBB Cost per Square Meter	0.006

Table 36, Cost per Unit Anderson Darling Test of Institutional Projects.

Figure 50 shows the time growth histograms of design and execution for Design-Bid-Build institutional projects.

The distribution of time growth for design and execution in DBB institutional projects is not normally distributed with a skew to the left.

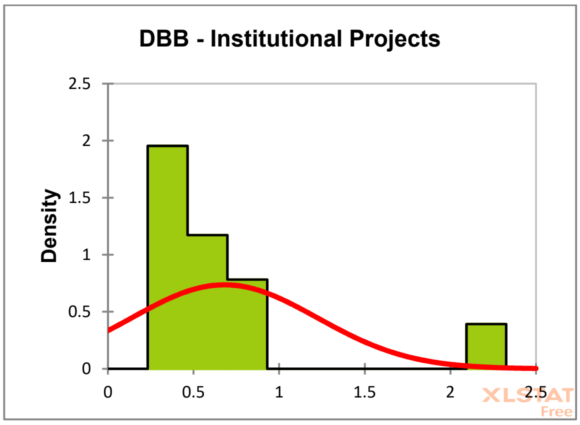


Figure 50, Histograms Time Growth for Design and Construction DBB Institutional Projects.

The Anderson Darling test results are shown in Table 37 and show that the Time growth for design and execution in DBB institutional projects is not normally distributed for the reason that the p-values are less than the significant alpha level of 0.05.

The null hypothesis assumes that the data is not normally distributed, if the p-value is less than the significant alpha level of 0.05.

#	Performance Time Metrics	p-value
1	DBB Design and Execution Time Growth	0.000

Table 37, Design and Execution Time Growth Anderson Darling Test of Institutional Projects.

Figure 51 shows the histograms of time growth for design and execution in DBB institutional projects.

The figures curve of DBB projects shows a non-normal distribution and the curve is skewed to the right because the *p*-alpha is less than 0.05.

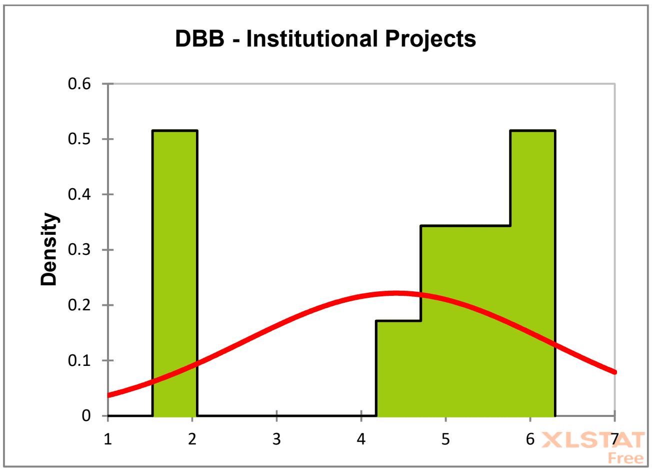


Figure 51, Histograms of Productivity for DBB Institutional Projects.

The Anderson Darling test results of productivity (Square Meter per Day) for institutional projects are shown in Table 38 and indicate that the DBB institutional projects are not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05 this result is rejected.

#	Performance Productivity Metrics	p-value
1	Productivity (m2/day)	0.007

Table 38, Productivity (m2/day) Anderson Darling Test of Institutional Projects.

4.3.1.4.2 - Unequal Variance Test

Table 39 shows the results of the Analysis of Variance (ANOVA) test for Cost Performance Metrics and indicates that the p-values for design and execution cost growth, as well as the variation order cost growth ratio, were more than 0.05. However, the p-value of cost per square meter was less than the significant alpha of 0.05.

Table 39 shows that the mean of design and execution cost growth, variation order cost growth ratio of DB institutional projects (6.70%, 3.20%, and 4,236 SR, respectively) is lower than that of the DBB institutional projects (4.27%, 3.97%, and 3,380 SR, respectively).

#	Cost Performance Metrics	Mean DBB (No.=08)	Critical Value	p-value
1	Design and Execution Cost Growth (%)	6.70	2.23	0.722
2	Variation Order Cost Growth Ratio (%)	3.20	2.23	0.869
3	Cost per Unit (SR/m2)	4,236	2.23	< 0.0001

Table 39, Results of T-test for unequal variance of Cost Performance Metrics for Institutional Projects.

Figure 52 shows the box plots for the design and execution cost growth metrics for Design-Bid-Build institutional projects. The figure shows that there are no higher or lower outliers.

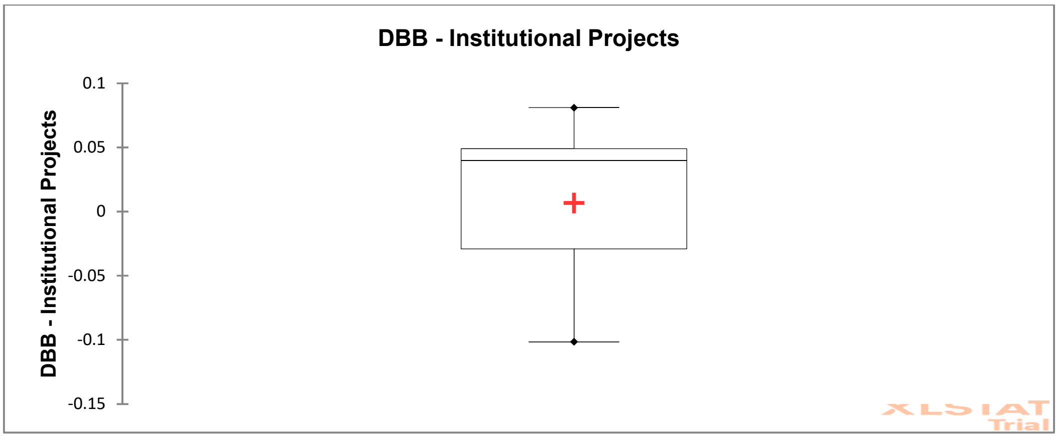


Figure 52 Box Plots of Cost Growth Performance Metrics for Institutional Projects.

Figure 53 shows the box plots of the variation order cost growth metrics for Design-Bid-Build institutional projects. The figure shows that there are no higher or lower outliers.

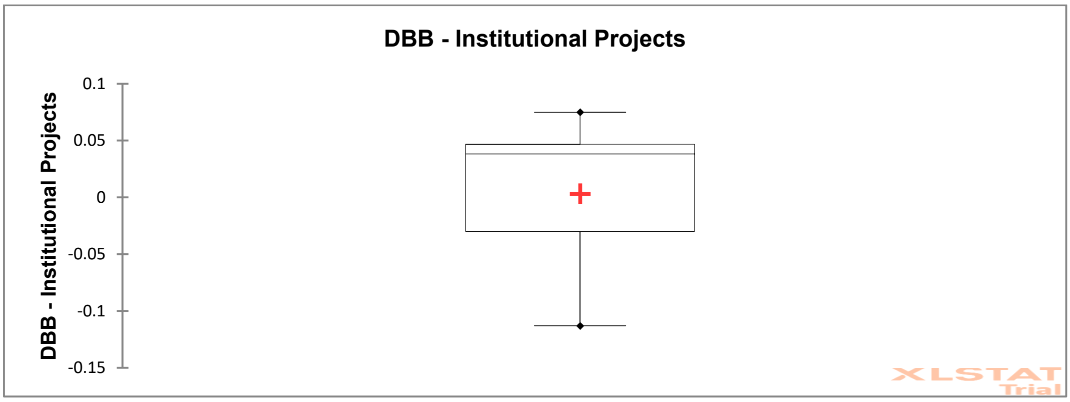


Figure 53, Box Plots of Variation Order Cost Ratio of Performance Metrics for Institutional Projects.

Figure 54 shows the box plots of cost per square meter metrics for Design-Bid-Build institutional projects. The figure shows that there is one higher outlier.

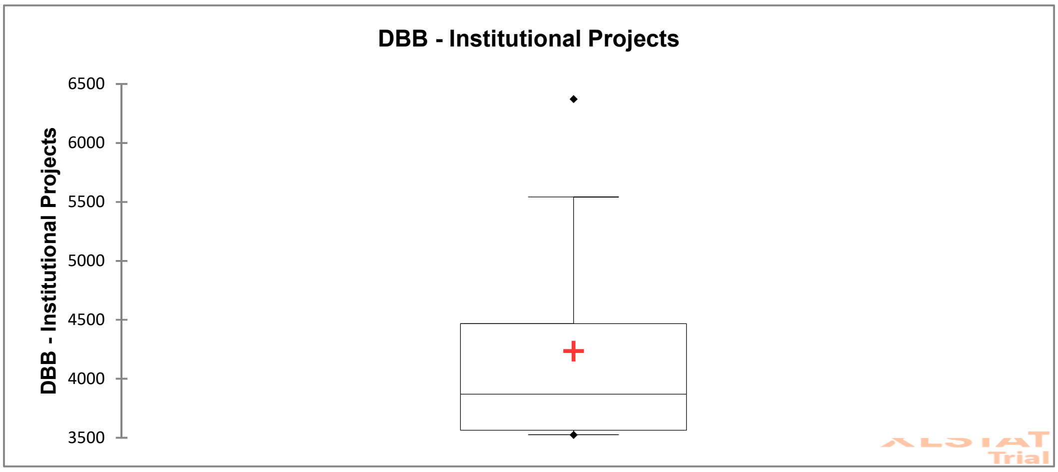


Figure 54, Box Plots of Unit Cost Performance per square meter Metrics for Institutional Projects.

Table 40 shows the results of the Analysis of Variance (ANOVA) test for Time Performance Metrics.

The p-values for both design and execution time growth are less than the significant alpha level of 0.05. However, the p-value of productivity is more than the significant alpha level of 0.05.

The mean of design and execution time growth is 68.13% and the mean of the productivity of DBB institutional projects is 4.41 Square Meters per Day.

#	Time Performance Metrics	Mean DBB (No.=11)	Critical Value	p-value
1	Design and Execution Time Growth (%)	68.13	2.23	0.002
2	Productivity (m2/day)	4.41	2.23	0.120

Table 40, Results of T-test for unequal variance of Time Performance Metrics for Institutional Projects.

Figure 55 shows the box plots of the design and execution performance metrics for Design-Bid-Build institutional projects. The figure shows that there is one higher outlier.

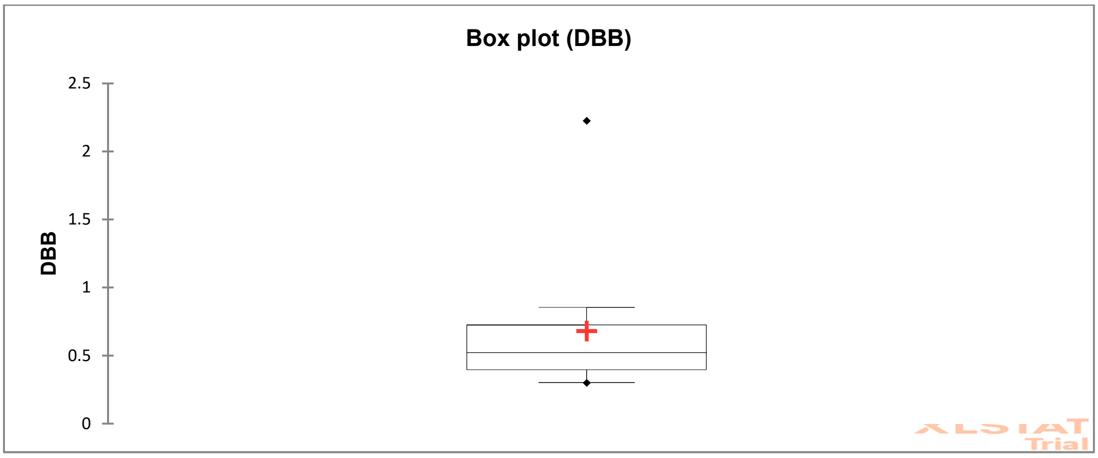


Figure 55 Box Plots of Time Growth Performance Metrics for Institutional Projects.

Figure 56 shows the box plots of productivity metrics for Design-Bid-Build institutional projects.

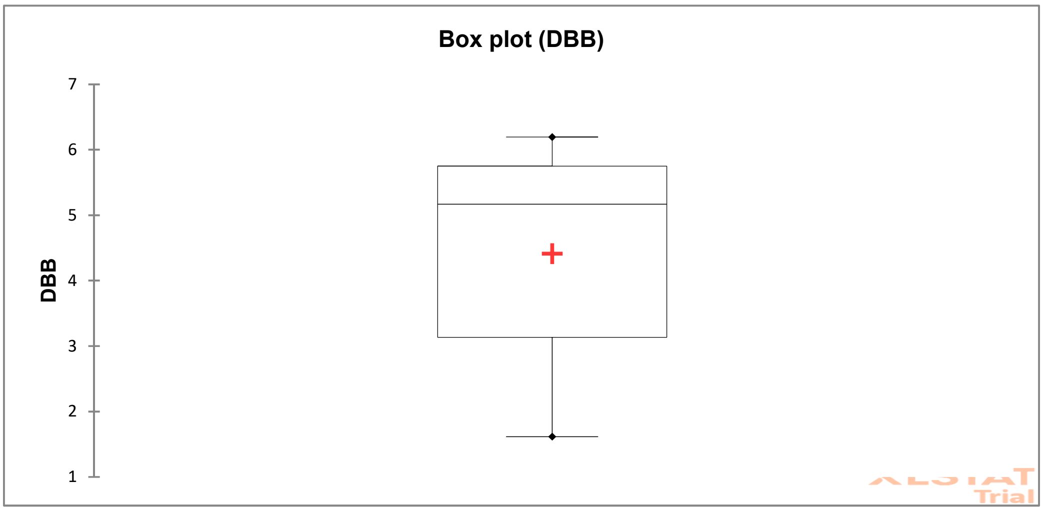


Figure 56, Box Plots of Productivity Performance Metrics for Institutional Projects.

4.3.1.5 - Infrastructure Projects

Table 41 illustrates the results indication of the mean, median and standard deviation of the cost performance metrics for Design-Build versus Design-Bid-Build Infrastructure Projects.

The results stated that the mean, median, and standard deviation values of Cost growth for design and execution in DB infrastructure projects (6.77%, 3.57%, and 8.80%, respectively) are higher than for DBB infrastructure projects (1.94%, 0.47%, and 5.07, respectively).

In addition, the table explains that the mean, median, and standard deviation values of variation order cost ratio values for DB infrastructure projects (6.77%, 3.57%, and 8.80%, respectively) are higher than for DBB infrastructure projects (1.71%, 0.47, and 4.85%, respectively).

These results mean that the cost performance of DB infrastructure projects is higher than for DBB infrastructure projects.

The mean, median, and standard deviation of cost per square meter for DB infrastructure projects are 22,664 SR, 15,280 SR, and 27,311 SR per square meter.

#	Cost Metrics	Design-Build Projects (No.=05)			Design-Bid-Build Projects (No.=05)		
		Mean	Median	SD	Mean	Median	SD
1	Design and Execution Cost Growth (%)	6.77	3.57	8.89	1.94	0.47	5.07
2	Variation Order Cost Growth Ratio (%)	6.77	3.57	8.89	1.71	0.47	4.85
3	Unit Cost (SR/m2)	22,664	15,280	27,311	N/A	N/A	N/A

Table 41, Cost performance metrics of DB versus to DBB Infrastructure Projects.

Table 42 indicates the mean, median, and standard deviation of time performance metrics for DB infrastructure projects versus DBB infrastructure projects.

The results stated that the mean and median of the Design and Execution Time Growth of DB infrastructure projects (28.46% and 46.15%, respectively) are lower than for DBB infrastructure projects (54.16% and 51.11%, respectively). However, the standard deviation of DB infrastructure projects (26.03%) is higher than for DBB infrastructure projects (17.03%).

The mean, median, and standard deviation of execution productivity (m2/day) for DB infrastructure projects are 203.04, 9.82, and 380.48, respectively.

#	Time Metrics	Design-Build Projects (No.=05)			Design-Bid-Build Projects (No.=05)		
		Mean	Median	SD	Mean	Median	SD
1	Design and Execution Time Growth (%)	28.46	46.15	26.03	54.16	51.11	17.03
2	Productivity (m2/day)	203.04	9.82	380.48	N/A	N/A	N/A

Table 42, Time performance metrics of DB Infrastructure projects versus to DBB Infrastructure Projects.

4.3.1.5.1 - Normality Test of Variance Analysis

Figure 57 shows he cost growth histograms of design and execution for Design-Build and Design-Bid-Build infrastructure projects.

The distribution of cost growth for design and execution in DB and DBB infrastructure projects are normally distributed with a skew to the left in DB projects and to the right in DBB projects.

The *p*-value of DBB infrastructure projects is more than 0.05 and that is the reason for normal distribution in the graphs.

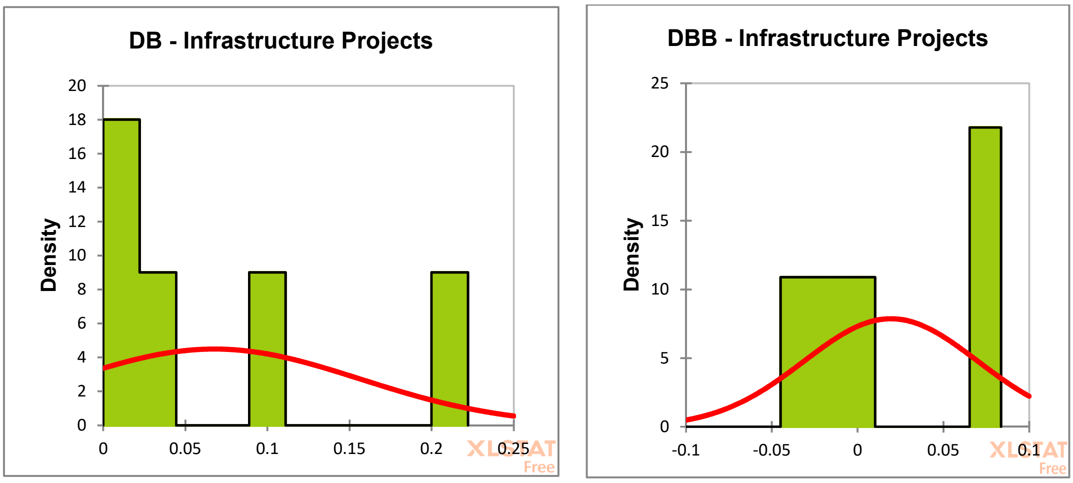


Figure 57, Histograms Cost Growth for Design and Construction in DB versus to DBB Infrastructure Projects.

The Anderson Darling test results are shown in Table 43. They show that the Cost growth for design and execution in both DB and DBB infrastructure projects is normally distributed for the reason that the p-value is more than the significant alpha level of 0.05. The null hypothesis assumes that the data is normally distributed, if the p-value is more than the significant alpha level 0.05.

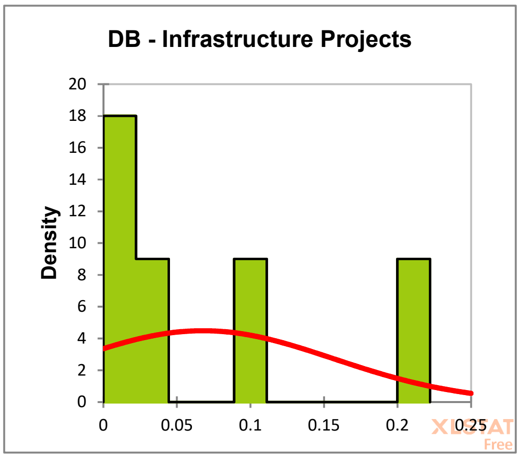
#	Performance Cost Metrics	p-value
1	DB Design and Execution Cost Growth	0.177
2	DBB Design and Execution Cost Growth	0.213

Table 43, Design and Execution Cost Growth Anderson Darling Test of Infrastructure Projects.

Figure 58 shows the cost growth histograms of variation order for Design-Build and Design-Bid-Build infrastructure projects.

The distribution of Variation order cost growth for DB and DBB infrastructure projects is normally distributed with a skew to the left in DB projects and to the right in DBB projects.

The *p*-value of DBB infrastructure projects is more than 0.05 and that is the reason for normal distribution in the graphs.



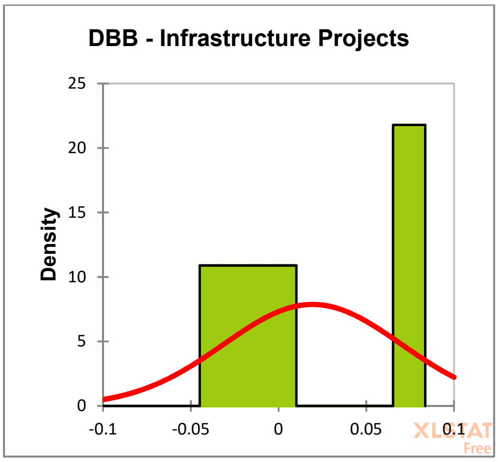


Figure 58, Histograms Cost Growth Ratio for Variation Order in DB versus to DBB Infrastructure Projects.

The Anderson Darling test results are shown in Table 44. They show that the Variation Order Cost Growth for both DB and DBB infrastructure projects is normally distributed for the reason that the p-value is more than the significant alpha level of 0.05.

The null hypothesis assumes that the data is normally distributed, if the p-value is more than the significant alpha level 0.05.

#	Performance Cost Metrics	p-value
1	DB Variation Order Cost Growth Ratio	0.177
2	DBB Variation Order Cost Growth Ratio	0.242

Table 44, Variation Order Cost Growth Ratio Anderson Darling Test of Infrastructure Projects.

Figure 59 shows the cost per square meter histograms for Design-Bid-Build infrastructure projects.

The distribution of cost per unit for DBB infrastructure projects is normally distributed with a skew to the left.

The *p*-value of DBB infrastructure projects is more than 0.05 and that is the reason for normal distribution in the graphs.

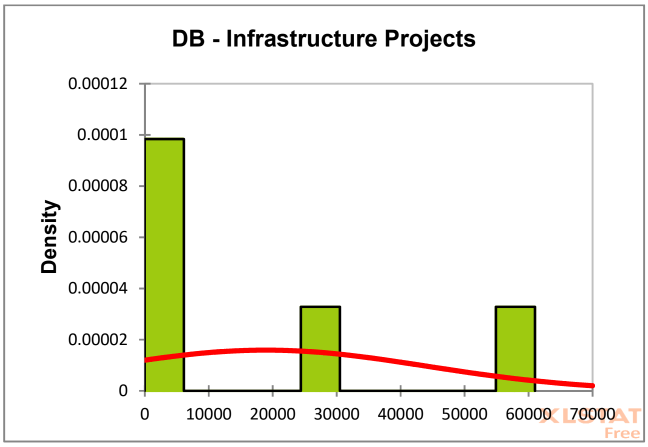


Figure 59, Histograms of cost per unit (SR/m2) for DB Infrastructure Projects.

The Anderson Darling test results of cost per square meter for DB infrastructure projects are shown in Table 45. They show that the DB infrastructure projects are normally distributed for the reason that the p-value is more than the significant alpha level of 0.05.

#	Performance Cost Metrics	p-value
1	DB Cost per Square Meter	0.091
2	DBB Cost per Square Meter	N/A

Table 45, Cost per Unit Anderson Darling Test of Infrastructure Projects.

Figure 60 shows the time growth histograms of design and execution for Design-Build infrastructure projects and Design-Bid-Build infrastructure projects.

The distribution of time growth for design and execution in DB infrastructure projects is not normal while for DBB infrastructure projects it is normally distributed.

The *p*-value for both DB projects is less than 0.05 and that is the reason for non-normal distribution in the graphs.

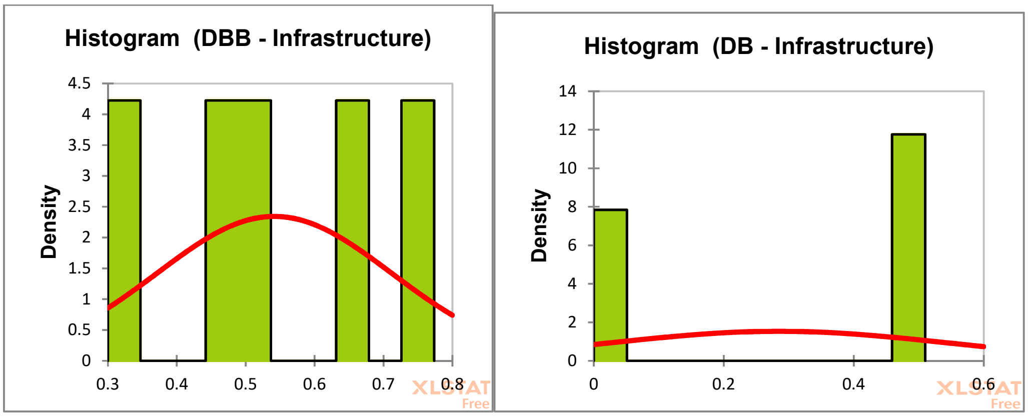


Figure 60, Histograms Time Growth for Design and Construction in DB versus to DBB Infrastructure Projects.

The Anderson Darling test results are shown in Table 46, They show that the Time growth for design and execution in DB infrastructure projects is not normally distributed for the reason that the p-values are less than the significant alpha level of 0.05. However, the Time growth for design and execution in DBB infrastructure projects is normally distributed for the reason that the p-value is higher than the significant alpha level 0.05.

The null hypothesis assumes that the data is not normally distributed, if the p-value is less than the significant alpha level 0.05.

#	Performance Time Metrics	p-value
1	DB Design and Execution Time Growth	0.025
2	DBB Design and Execution Time Growth	0.874

Table 46, Design and Execution Time Growth Anderson Darling Test of Infrastructure Projects.

Figure 61 shows the histograms of time growth for design and execution in DB infrastructure projects.

The figures curve of DBB projects shows non-normal distribution and the curve is skewed to the left because the *p*-alpha is less than 0.05.

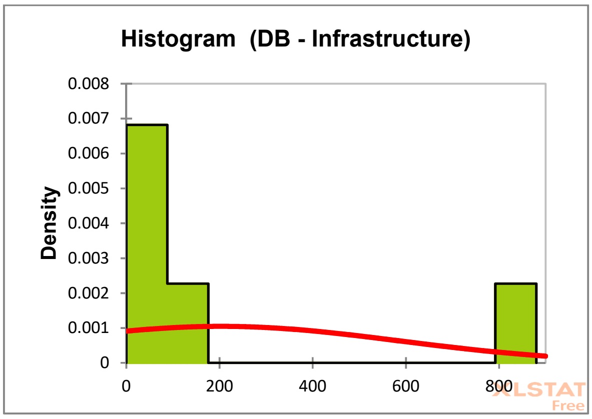


Figure 61, Histograms of Productivity for DBB Infrastructure Projects.

The Anderson Darling test results of productivity (Square Meter per Day) for DB infrastructure projects are shown in Table 47. They indicate that the productivity performance is not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05 this result is rejected.

#	Performance Productivity Metrics	p-value
1	DB Productivity (m2/day)	0.006
2	DBB Variation Order Cost Growth Ratio	N/A

Table 47, Productivity (m2/day) Anderson Darling Test of Infrastructure Projects.

4.3.1.5.2 - Unequal Variance Test

Table 48 shows the results of the Analysis of Variance (ANOVA) test for Cost Performance Metrics and indicates that the p-values for all cost performance metrics are more than 0.05. The null hypothesis for the mean of cost performance metrics in DB and DBB infrastructure projects is accepted. However, table 51 shows that the mean of design and execution cost growth, the Variation order cost growth ratio of DB infrastructure projects (7.02% and 7.02% respectively), is higher than that of DBB infrastructure projects (2.13% and 2.13%, respectively). The cost per unit for DB infrastructure projects is 18,931 SR per square meter.

#	Cost Performance Metrics	Mean		Critical Value	p-value
		DB (No.=02)	DBB (No.=08)		
1	Design and Execution Cost Growth (%)	7.02	2.13	2.31	0.321
2	Variation Order Cost Growth Ratio (%)	7.02	2.13	2.31	0.296
3	Cost per Unit (SR/m2)	18,931	N/A	2.31	0.130

Table 48, Results of T-test for unequal variance of Cost Performance Metrics for Infrastructure Projects.

Figure 62 shows the box plots that compare the design and execution cost growth metrics of Design-Build versus Design-Bid-Build infrastructure projects. The figure shows that there are higher outliers of Design and Execution Cost Growth Performance for DB infrastructure projects than for DBB infrastructure projects.

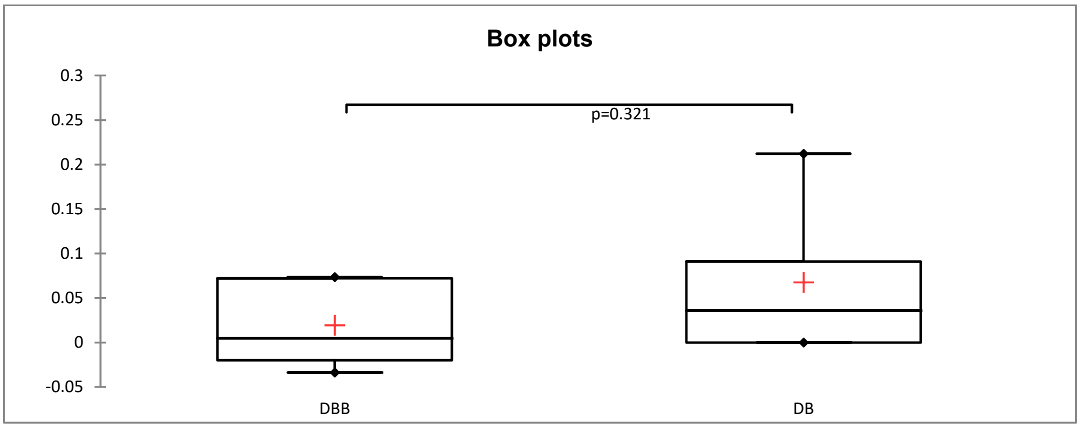


Figure 62, Infrastructure Projects Box Plots for Cost Growth.

Figure 63 shows the box plots that compare the Variation order cost growth ratio metrics of Design-Build versus Design-Bid-Build infrastructure projects and shows that there are higher outliers of Variation Order Cost Growth Ratio Performance for DB infrastructure projects than for DBB infrastructure projects.

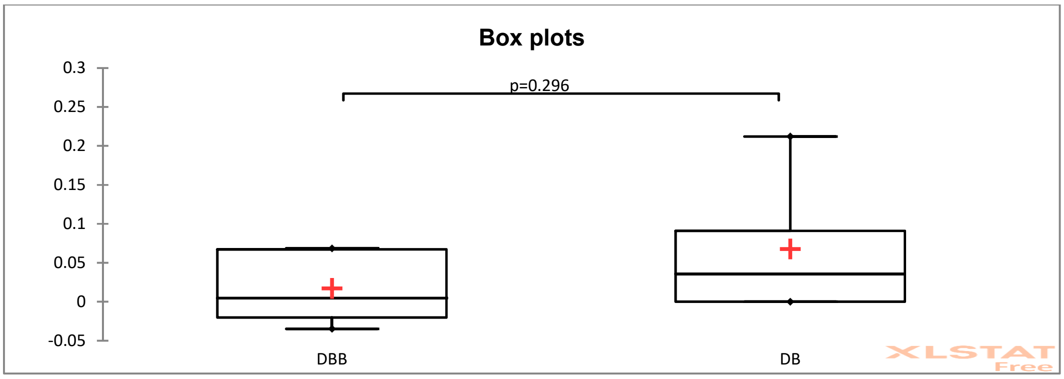


Figure 63, Box Plots of Variation Order Cost Ratio of Performance Metrics for Infrastructure Projects.

Figure 64 shows the box plots that compare the cost per square meter metrics of Design-Build versus Design-Bid-Build infrastructure projects and shows that there are higher outliers of Cost per Square Meter Performance for DB infrastructure projects than for DBB infrastructure projects. Furthermore, there is one higher outlier for DB infrastructure projects.

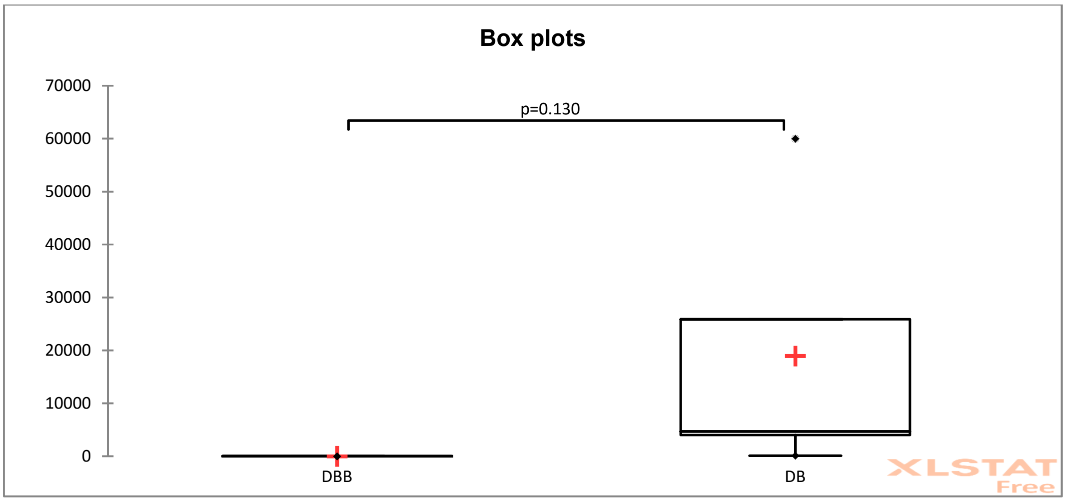


Figure 64, Box Plots of Unit Cost Performance per square meter Metrics for Infrastructure Projects.

Table 49 shows the results of the Analysis of Variance (ANOVA) test for Time Performance Metrics.

The mean of Design and Execution Time Growth for DBB infrastructure projects (54.16%) is higher than for DB INFRASTRUCTURE projects (28.46%). Meanwhile, the difference between DB and DBB infrastructures was not significant for the reason that the p-value of design and execution time growth and productivity is more than the significant alpha level of 0.05.

#	Time Performance Metrics	Mean		Critical Value	p-value
		DB (No.=05)	**DBB (No.=05)**		
1	Design and Execution Time Growth (%)	28.46	54.16	2.31	0.102
2	Productivity (m2/day)	203.04	N/A	2.78	0.299

Table 49, Results of T-test for unequal variance of Time Performance Metrics for Infrastructure Projects.

Figure 65 shows the box plots that compare the design and execution time growth metrics of Design-Build versus Design-Bid-Build infrastructure projects. The figure shows that there are higher outliers of Design and Execution Time Growth Performance for DBB infrastructure projects than for DB infrastructure projects.

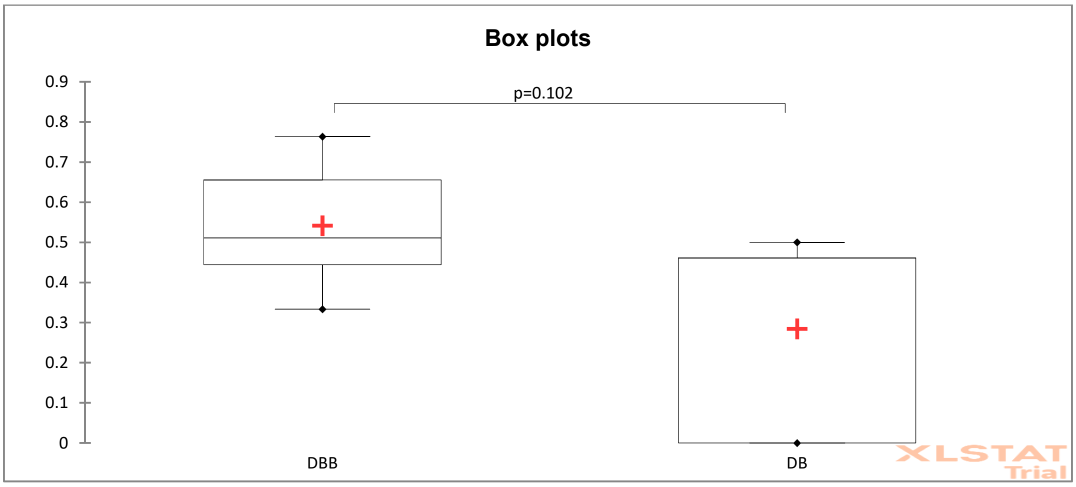


Figure 65, Infrastructure Projects Box Plots for Time Growth.

4.3.1.6 - DB and DBB Projects in general

Table 50 illustrates the results indication for the mean, median and standard deviation of the cost performance metrics for Design-Build Projects versus Design-Bid-Build Projects.

The results stated that the mean values of Cost growth for design and execution in DB and DBB projects are very similar with percentages of 11.5% and 10.1%, respectively. However, the median of the values of DB projects (9%) is higher than for DB projects (4.1%). The standard Deviation of DB projects (16%) is lower than for DBB projects (22.2%). The results show that the design and execution cost growth for DB projects is higher than for DBB projects.

In addition, the table explains that the mean, median, and standard deviation values of variation order cost ratio values for DB projects (11.5%, 9%, and 16%, respectively) is higher than for the values of DBB projects (5.7%, 3.9%, and 10.6, respectively). These results indicate that the Variation order cost ratio of DB projects is bigger than for DBB projects.

The mean, median, and standard deviation cost per square meter of DB projects (11,416 SR, 4,000 SR, and 18,974 SR, respectively) is higher than for DBB projects (5,783 SR, 3,607 SR, and 6,021 SR, respectively). The results show that the cost per square meter of DB projects is higher than for DBB projects.

Descriptive Statistics of Cost Metrics

#	Cost Metrics	Design-Build Projects (No.=11)			Design-Bid-Build Projects (No.=44)		
		Mean	Median	SD	Mean	Median	SD
1	Design and Execution Cost Growth (%)	11.5	9	16	10.1	4.1	22.2
2	Variation Order Cost Growth Ratio (%)	11.5	9	16	5.7	3.9	10.6
3	Unit Cost (SR/m2)	11,416	4,000	18,974	5,783	3,607	6,021

Table 50, Cost performance metrics of DB versus to DBB Projects

Table 51 indicates the mean, median, and standard deviation of time performance metrics for DB projects versus DBB projects.

The results stated that the mean, median, and standard deviation of the Design and Execution Time Growth of DB projects (22%, 22%, and 27%, respectively) is lower than for DBB projects (75%, 59%, and 52%, respectively). These results mean that the total design and execution duration of DBB projects is more than that of DB projects.

The mean of execution productivity for DB projects (214.19 m2/day) is higher than the mean of DBB projects (11.29 m2/day).

In addition, the median of DB projects (30.45 m2/day) is bigger than that of DBB projects (5.45 m2/day).

The table indicates that the standard deviation of the DB projects' productivity was also higher than that of the DBB projects' productivity by 364m2/day and 22.47m2/day, respectively. These results mean that the productivity of the DB projects was higher than that of the DBB projects.

#	Time Metrics	Design-Build Projects (No.=11)			Design-Bid-Build Projects (No.=44)		
		Mean	Median	SD	Mean	Median	SD
1	Design and Execution Time Growth (%)	26	22	27	75	59	52
2	Productivity (m2/day)	214.19	30.45	364.98	11.29	5.45	22.47

Table 51, Time performance metrics of DB projects versus to DBB Projects.

4.3.1.6.1 - Normality Test of Variance Analysis

Figure 66 shows the cost growth histograms of design and execution for Design-Build projects and Design-Bid-Build projects.

The distribution of cost growth for design and execution in DB and DBB projects is not normal. Meanwhile, the histograms show that the normal distribution of DB projects is higher than for DBB projects. The DB curve is skewed to the left only slightly more than the DBB curve.

The *p*-values for both DB and DBB projects are less than 0.05 and that is the reason for the non-normal distribution in the graphs.

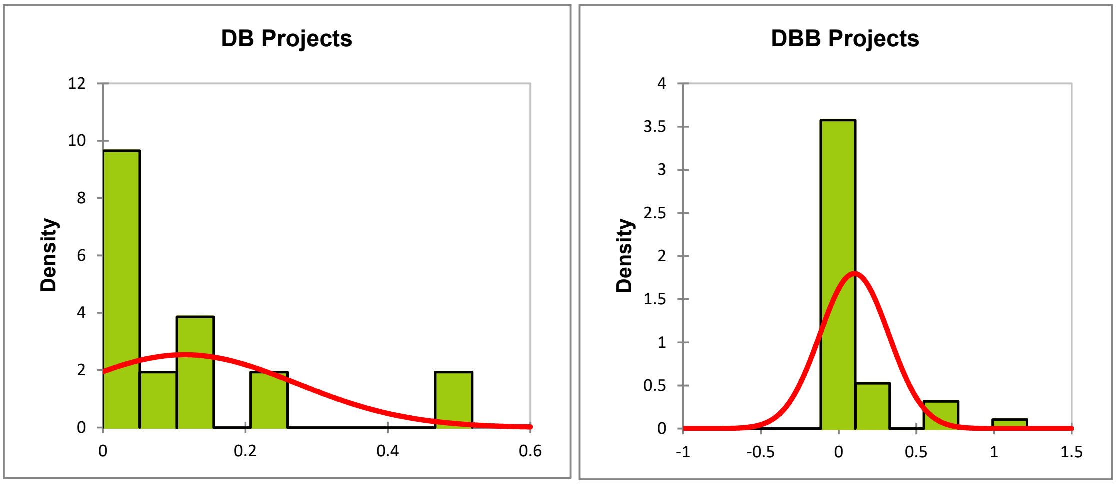


Figure 66, Histograms Cost Growth for Design and Construction in DB versus to DBB Projects.

The Anderson Darling test results are shown in table 52. They show that the Cost growth for design and execution in DB and DBB projects is not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05, this result is rejected. However, the results of the normality test will not be affected if the sample size is more than 30 samples.

#	Performance Cost Metrics	p-value
1	DB Design and Execution Cost Growth	0.012
2	DBB Design and Execution Cost Growth	< 0.0001

Alpha Level is 0.05

Table 52, Design and Execution Cost Growth Anderson Darling Test.

Figure 67 illustrates the variation order cost growth ratio histograms for DB and DBB projects.

The figure shows that the curve which is skewed to the left of the DB projects is higher than that of the DBB projects. DBB projects have a normal distribution with a little skew to the left.

The distribution of Cost growth ratio for variation order in DB and DBB projects was not normal.

The *p* alphas for both DB and DBB projects were less than 0.05 and that is the reason for non-normal distribution in the graphs.

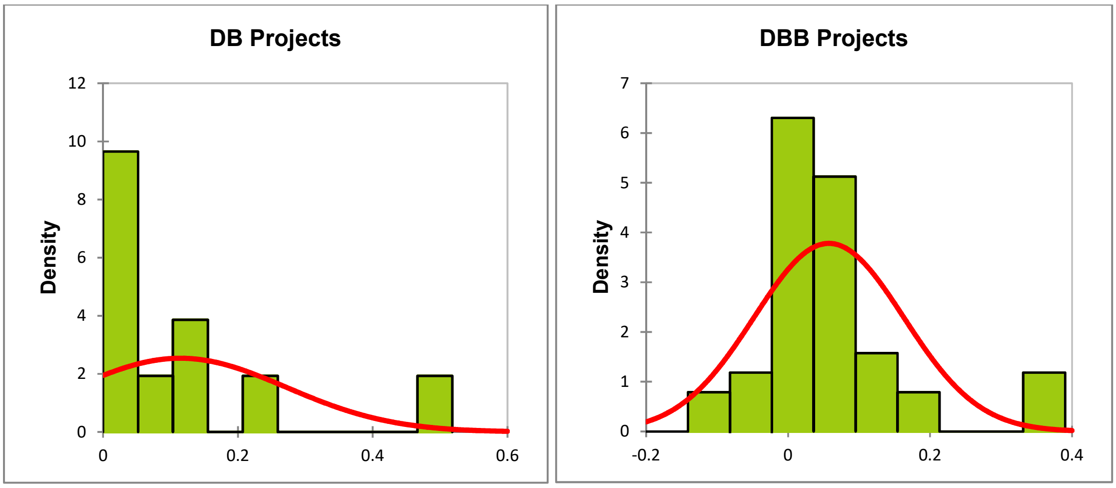


Figure 67, Histograms Cost Growth Ratio for Variation Order in DB versus to DBB Projects.

The Anderson Darling test results for Variation Order Cost Growth are shown in Table 53. They show that the DB and DBB projects are not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05, this result is rejected. However, the results of the normality test will not be affected if the sample size is more than 30 samples.

Meanwhile, the graph shows that the DBB projects have a little normal distribution, while the Anderson Darling test shows the opposite of that.

#	Performance Cost Metrics	p-value
1	DB Variation Order Cost Growth Ratio	0.012
2	DBB Variation Order Cost Growth Ratio	< 0.0001

Table 53, Variation Order Cost Growth Ratio Anderson Darling Test

Figure 68 illustrates the Histograms of cost per unit (SR/m2). The histograms curve of DB and DBB projects shows non-normal distribution and both curves were skewed to the left because the *p* alpha is less than 0.05.

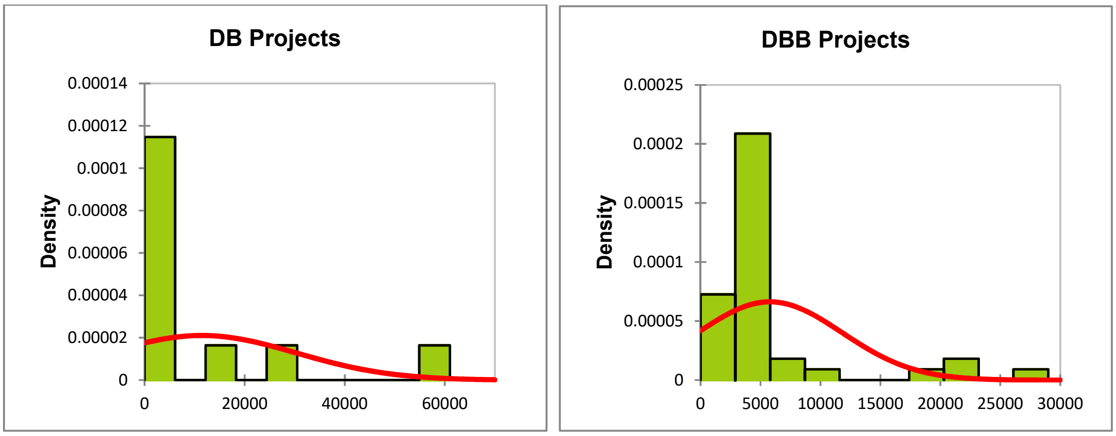


Figure 68, Histograms of cost per unit (SR/m2) for DB versus to DBB projects

The Anderson Darling test results for Cost per Square Meter are shown in table 54. They show that the DB and DBB projects are not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level of 0.05, this result is rejected. However, the results of the normality test will not be affected if the sample size is more than 30 samples.

#	Performance Cost Metrics	p-value
1	DB Cost per Square Meter	0.0005
2	DBB Cost per Square Meter	< 0.0001

Table 54, Cost per Unit Anderson Darling Test

Figure 69 shows the histograms of time growth for design and execution in DB projects and DBB projects.

The figures curve of the DBB projects show a non-normal distribution and the curve was skewed to the left because the *p*-alpha is less than 0.05.

The DB projects show a normal distribution with a little skew to the left.

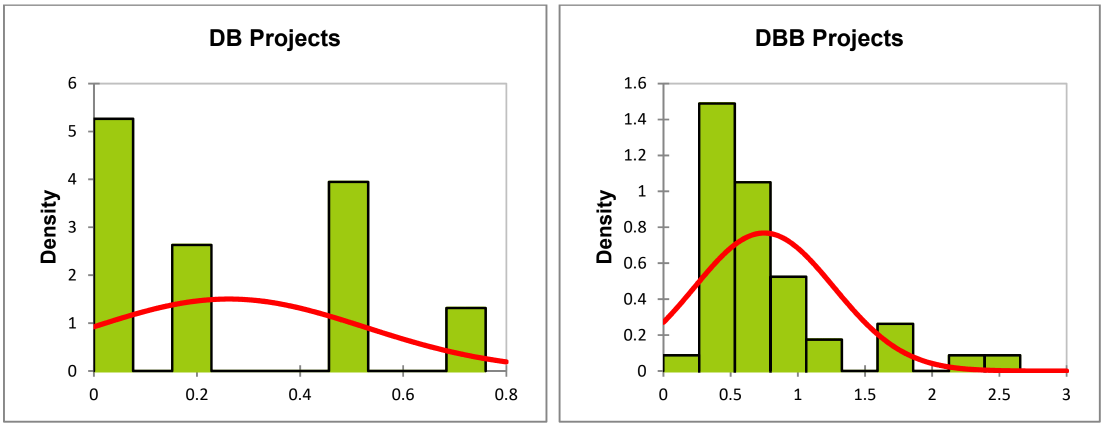


Figure 69, Histograms Time Growth for Design and Construction in DB versus to DBB Projects.

The Anderson Darling test results for Design and Execution Time Growth are shown in Table 55. They show that the DB projects are not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05. The null hypothesis assumes that the data will be normally distributed, if the p-value is more than the significant alpha level 0.05, so this result is rejected. However, the results of the normality test will not be affected if the sample size is more than 30 samples.

Table 55 also shows that the DBB projects are normally distributed for the reason that the p-value is more than the significant alpha level 0.05. Meanwhile, the graph shows that DBB projects don't have a completely normal distribution.

#	Performance Time Metrics	p-value
1	DB Design and Execution Time Growth	0.139
2	DBB Design and Execution Time Growth	< 0.0001

Table 55, Design and Execution Time Growth Anderson Darling Test

Figure 70 shows the histograms of productivity for DB and DBB projects. The figures curve of the DB and DBB projects show a non-normal distribution and both curves are skewed to the left for the reason that the *p* alpha is less than 0.05. The curve skews to the left in the DBB projects more than for the DB projects. The DB projects have a normal distribution with a little skew to the left.

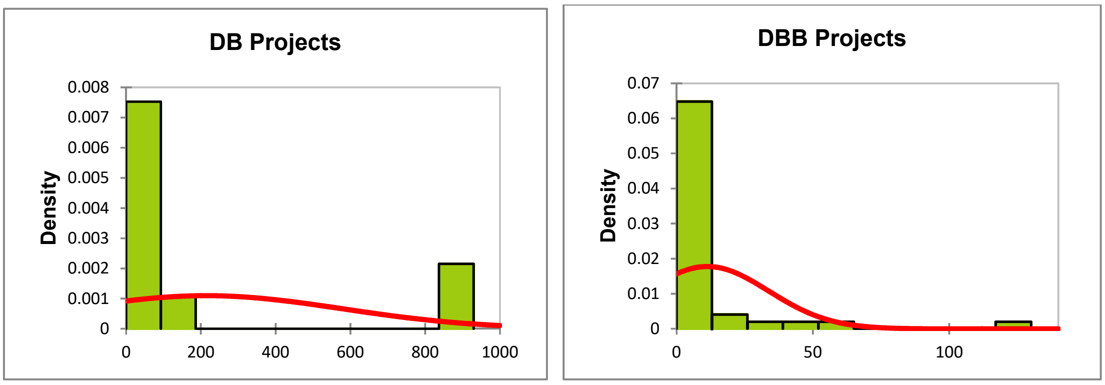


Figure 70, Histograms of Productivity for DB versus to DBB projects

The Anderson Darling test results for Productivity (m2/day) are shown in Table 56. They show that the DB and DBB projects are not normally distributed for the reason that the p-value is less than the significant alpha level of 0.05.

The null hypothesis assumes that the data will be normally distributed. If the p-value is more than the significant alpha level 0.05, this result is rejected. However, the results of the normality test will not be affected if the sample size is more than 30 samples.

#	Performance Productivity Metrics	p-value
1	DB Productivity (m2/day)	< 0.0001
2	DBB Productivity (m2/day	< 0.0001

Table 56, Productivity (m2/day) Anderson Darling Test

4.3.1.6.2 - Equal Variance Test

To verify the homogeneity of variance for the DB and DBB projects, this study conducted Levene's test.

As per the null hypothesis for Levene's test the variances of the DB and DBB projects are equal.

In the case that the p-value is lower than the significant alpha level of 0.05, the null hypothesis of variances will be rejected.

Levene's test is applied for Cost Performance Metrics as shown in Table 11.

All of the p-values of the cost performance metrics were less than the significant alpha level of 0.05. Hence, the variances of all cost performance metrics.

Table 57 shows the Homogeneity Test of the Cost Performance Metrics for DB and DBB projects and indicates that the p-value for Design and Execution Cost Growth, as well as the Variation Order Cost Growth Ratio, is more than the significant alpha level 0.05.

In addition, the p-value for Cost per Square Meter is less than the significant alpha level 0.05. This means that the null hypothesis is rejected and the variance of cost per unit for DB and DBB projects is not equal. Therefore it is preferable to use the statistical t-test comparison for the mean of Cost per Unit for DB and DBB projects.

#	Performance Cost Metrics	p-value
1	Design and Execution Cost Growth	0.705
2	Variation Order Cost Growth Ratio	0.177
3	Cost Unit (SR/m2)	0.0004

Table 57, Variance Homogeneity Test for Cost Performance Metrics

Table 58 shows the Homogeneity Test of Time Performance Metrics for the DB and DBB projects and indicates that the p-value for Design and Execution Time Growth is more than the significant alpha level of 0.05.

In addition, the p-value for productivity is less than the significant alpha level of 0.05. This means that the null hypothesis is rejected and the variance of productivity for DB and DBB projects is not equal. Therefore it is preferable to use the statistical t-test comparison for the mean of productivity for DB and DBB projects.

#	Performance Time Metrics	p-value
1	Design and Execution Time Growth	0.215
2	Productivity (m2/day)	< 0.0001

Table 58, Variance Homogeneity Test for Time Performance Metrics

Table 59 shows the results of the Analysis of Variance (ANOVA) test for Cost Performance Metrics and indicates that the p-values for all cost performance metrics are more than 0.05. The null hypothesis for the mean of cost performance metrics in DB and DBB projects is accepted.

#	Cost Performance Metrics	Mean		Critical Value	p-value
		DB (No.=11)	DBB (No.=44)		
1	Design and Execution Cost Growth (%)	11.46	10.09	2.01	0.855
2	Variation Order Cost Growth Ratio (%)	11.46	5.74	2.01	0.168
3	Cost per Unit (SR/m2)	11,416	5,783	2.01	0.119

Table 59, Results of T-test for unequal variance of Cost Performance Metrics

Figure 71 shows the box plots that compare the cost growth metrics of Design-Build versus Design-Bid-Build projects. The figure shows that there are higher outliers of Cost Growth Performance for DBB projects than for DB projects. There are two outliers for the Cost Growth of DB projects, while DBB projects have six outliers.

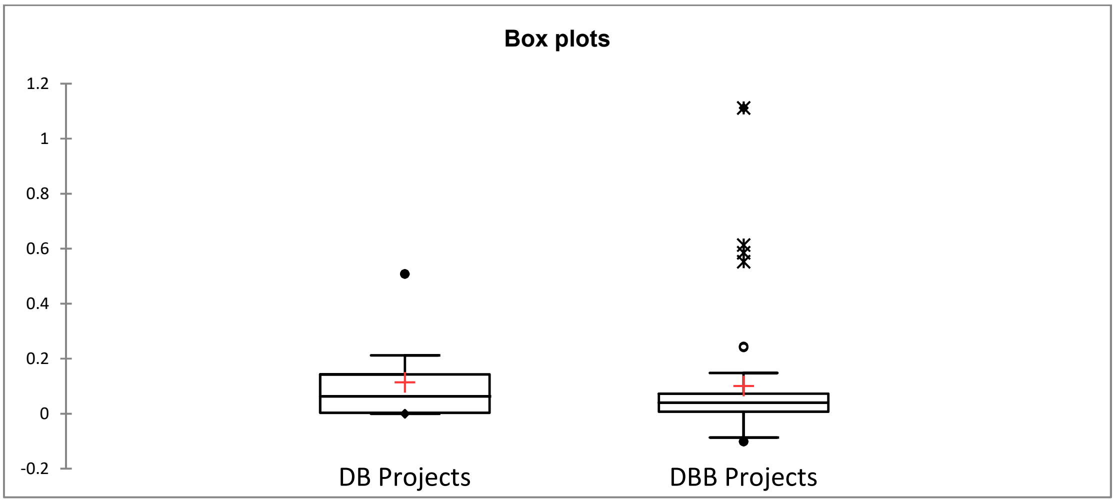


Figure 71, Box Plots of Cost Growth Performance Metrics

Figure 72 shows the box plots that compare the Variation Order Cost growth Ratio metrics of Design-Build versus Design-Bid-Build projects.

The figure shows that there are higher outliers of Variation Order Cost growth Ratio Performance for DBB projects than for DB projects. There are just two outliers for Cost growth ratio for the variation order in DB projects, while for DBB projects there are five outliers.

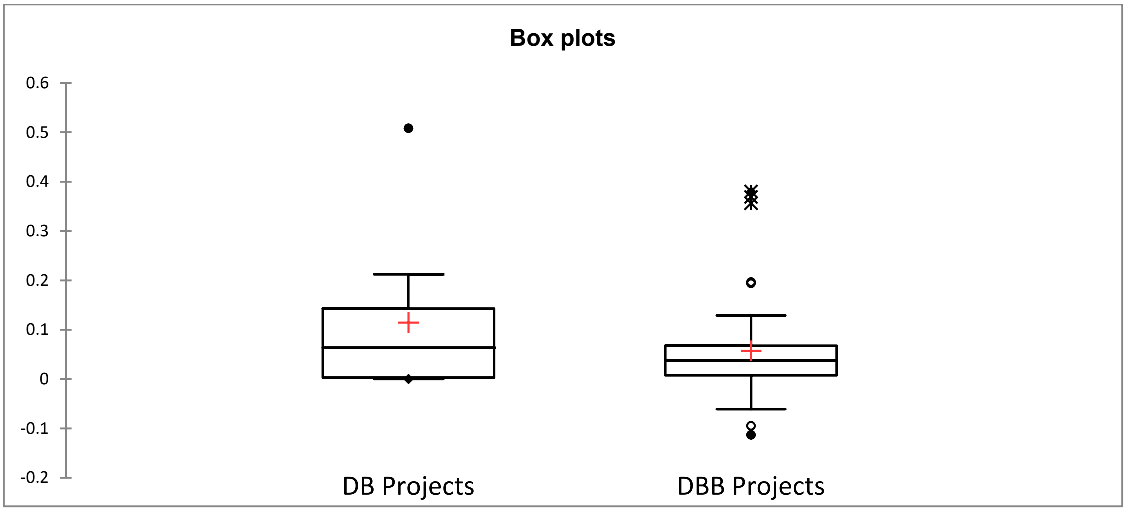


Figure 72, Box Plots of Variation Order Cost Ratio of Performance Metrics.

Figure 73 shows the box plots that compare the Unit Cost per square meter metrics of Design-Build versus Design-Bid-Build projects.

The figure indicates that there are lower outliers of Unit Cost Performance per square meter for DB projects than for DBB projects. There are just two outliers for Unit Cost per square meter for DB projects, while for DBB projects there are five outliers.

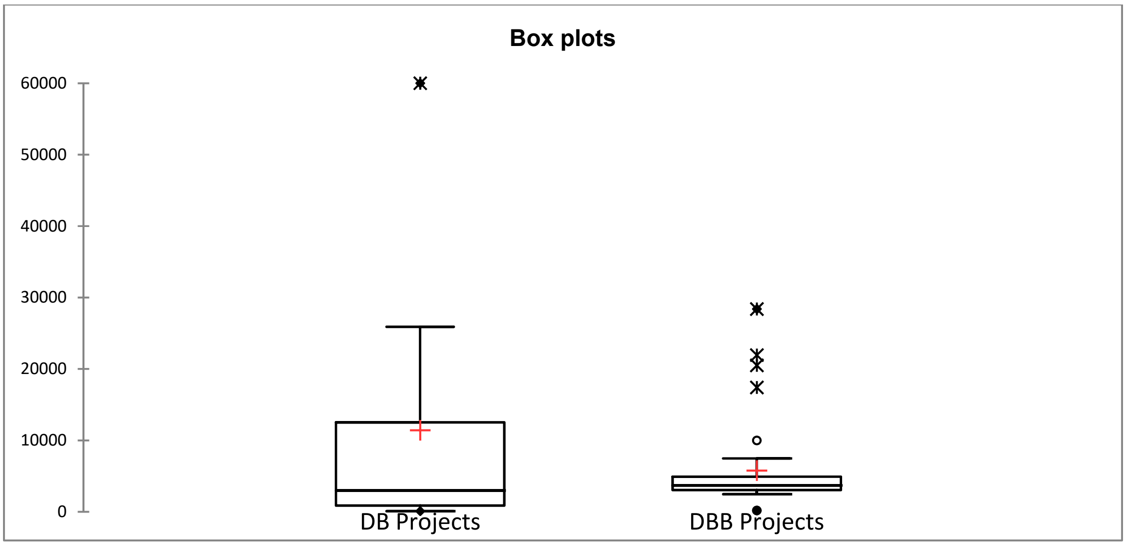


Figure 73, Box Plots of Unit Cost Performance per square meter Metrics

In general, both DB and DBB projects have outliers for cost growth, variation order cost growth ratio and unit cost per square meter.

Table 60 shows the results of the Analysis of Variance (ANOVA) test for Time Performance Metrics.

The mean of Design and Execution Time Growth, as well as the productivity in DB projects, are significantly higher than the mean of DBB projects for the reason that the p-values for Design and Execution Time Growth are almost equal to alpha level 0.05.

However, the p-value of productivity is less than the significant alpha level 0.05 as indicated in table 60 below.

#	Time Performance Metrics	Mean		Critical Value	p-value
		DB Projects	DBB Projects		
1	Design and Execution Time Growth (%)	26.18	74.95	2.01	0.006
2	Productivity (m2/day)	214.19	11.29	2.48	< 0.0001

Table 60, Results of T-test for unequal variance of Time Performance Metrics

The box plots of the time growth metrics are indicated in figure 74, and it is stated that the time growth outliers for DB projects is lower than for DBB projects. The DBB projects have five outliers and the DB projects have just two outliers and they are closed to the variance.

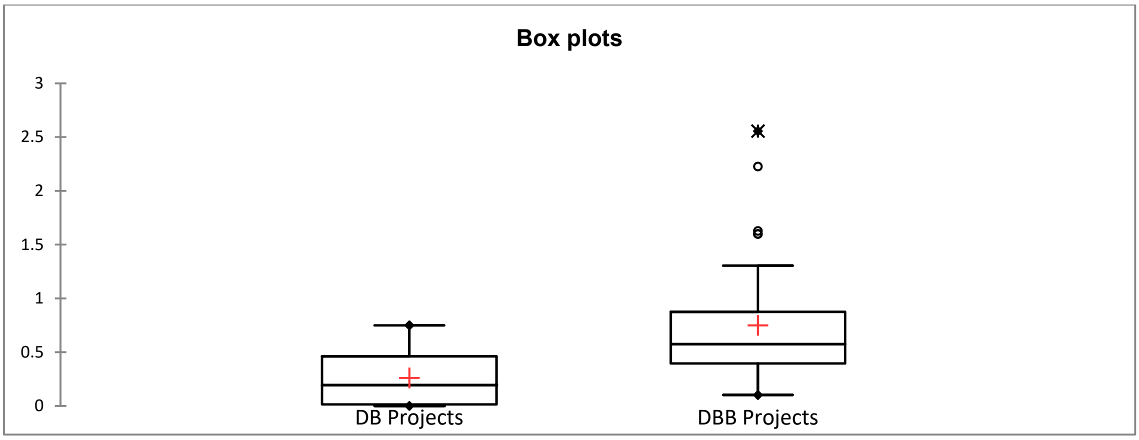


Figure 74, Box Plots of Time Growth Performance Metrics

Figure 75 shows the box plots that compare the productivity performance metrics of Design-Build versus Design-Bid-Build projects.

The figure indicates that there are lower outliers of productivity performance for DB projects than for DBB projects. There are three outliers for DB projects, and six outliers for DBB projects.

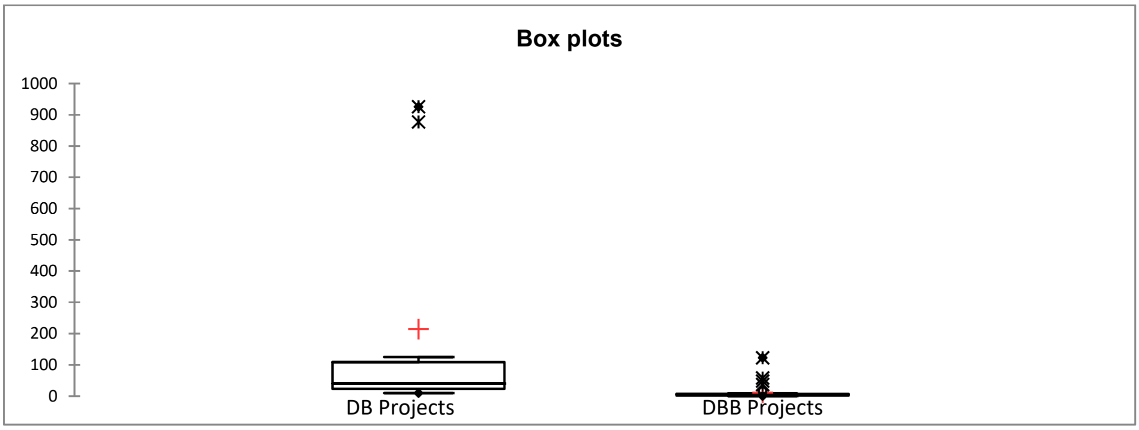


Figure 75, Box Plots of Productivity Performance Metrics

4.4- Factors hindering the implementation of a DB delivery system in Saudi Arabia.

The second aim of this study aimed to study the factor influences of not utilizing the Design-Build delivery method in the execution industries field and to rank the level of agreement and disagreement of the influences that affect not utilizing the Design-Build delivery method.

Due to the substantial number of the influences they were analyzed by group and then the mean of each group were compared. Finally, arrange the rank of the important factors that affect the non selection of the Design-Build delivery method.

Tables 61 and 62 show the organization capital in million SR and the organization average million SR per year of execution contracts, respectively.

The highest number of organization had capital of less than 1 million and the highest average million per year of execution contracts was less than 100 million.

#	**Organization Capital in millions SR**	**No.**
1	Less than 1 million	23
2	From 1 to 10 million	12
3	From 10 to 50 million	7
4	From 50 to 100 million	3
5	From 100 to 500 million	1
6	More than 500 million	7

Table 61, Organization Capital in millions SR

#	**Organization average million SR per year of execution contracts**	**No.**
1	Less than 100 million	18
2	From 100 to 200 million	15
3	From 200 to 500 million	5
4	From 500 to 700 million	6
5	From 700 to 1,000 million	2
6	More than 1,000 million	7

Table 62, Organization average million SR per year of execution contracts

Table 63 shows the highest numbers of organization age in year was that from 10 to 15 years and more than 25 years. The lowest numbers of organization age was less than 5 years.

#	Organization Age in year	No.
1	Less than 5 years	2
2	From 5 to 10 years	12
3	From 10 to 15 years	13
4	From 15 to 20 years	5
5	From 20 to 25 years	7
6	More than 25 years	13

Table 63, Organization Age per year

Table 64 shows the descriptive statistics for influences that affect not utilizing the DB delivery method and indicates the rank of important factors that affect non-selection of the DB delivery method, as well as the mean and standard deviation for each factor and for all factors.

The biggest mean (4.14) was for clarity of scope of work by the owner at the earlier time and the smallest mean (2.76) was that the owner was not much involved in the project stages.

The four important factors that affect execution project industries in Saudi Arabia to not select the DB delivery method for their own projects was ranked respectively by mean (4.14, 4.02, 3.96, and 3.75) as the Clarity of scope of work at an earlier time by the owner and expectation of high estimated cost by the contractor and expected a lot of variations during the design and execution stage and the capabilities of the owner's team work. 41% of respondents selected strongly agree and 0% selected disagree with the Clarity of scope of work by the owner at an earlier time and 41% selected agree and 0%

selected strongly agree with the expected high cost and 39% selected agree and 0% selected strongly disagree with the expected many variations during the design and execution stages and 47% selected agree and 0% selected disagree with the capabilities of the owner's team work.

A clear scope of work is important at the earlier time to guide the contractors to prepare their commercial and technical proposal and avoid expecting a high estimated cost by contractor due to the missed clarity of scope of work at an earlier time and expected a lot of variations during the design and execution stages.

The second factor was the expectation of a high estimated cost by the contractor which will lead the contractor to submit a high estimated cost in case there is no clear scope of work.

The lowest factors that affect the client's selection of DB delivery method were ranked in table 19, respectively, as the owner is not very involved in the project stages by mean 2.76, 27% our of respondents disagreed and 12% strongly agreed and the negative expectation of the time performance factor by mean 2.80, 27% our of respondents disagreed while just 10% strongly agreed and the lack of quality expectation factor by mean 2.88, 35% our of respondents disagreed while just 10% strongly agreed unpredictability of expectation performance of Design-Build by mean 3.25, 35% our of respondents were neutral and 39% agreed and follow government procurements by mean 3.39, 29% our of respondents were neutral and 41% agreed.

The clients in the DB delivery methods will have a single contract agreement with one organization and transfer to them the responsibilities of the design and execution stage. One of the advantages of the DB delivery method is executing the projects with overlaps between the design and execution stages.

The factors no. 8, 5, 7, 4, and 6 have a mean between the highest and lowest factors mean. The mean for these factors was 3.69, 3.63, 3.59, 3.41, and 3.39, respectively, and the description of these factors was:

1- Not common of Design-Build on the market
2- No professional practice by contractors
3- Missed understanding of the principle of Design-Build
4- Capabilities of contractors at market.
5- Follow Government procurement system

The DB delivery method is not common in the market due to the government's procurement for their project and the selection of the DBB delivery method for most of government projects.

No professional practice for contractors to deal with conflicts of interest that happen during project execution under DB delivery methods. Capabilities of team work is one of the factors of successful DB projects.

#	Question		Strongly Disagree	Dis-agree	Neutral	Agree	Strongly Agree	Mean	SD	Rank
1	Capabilities of owner team work.	N	4	0	12	24	11	3.75	1.06	4
		%	8%	0%	24%	47%	22%			
2	Clarity of scope of work is not determined at earlier time by owner	N	2	2	7	16	24	4.14	1.06	1
		%	4%	4%	14%	31%	47%			
3	Expectation of many Variations during design and execution	N	0	5	9	20	17	3.96	0.96	3
		%	0%	10%	18%	39%	33%			
4	Capabilities of contractors at market.	N	3	6	19	13	10	3.41	1.12	8
		%	6%	12%	37%	25%	20%			
5	No professional practice by contractors	N	4	5	12	15	15	3.63	1.23	6
		%	8%	10%	24%	29%	29%			
6	Follow Government procurement system	N	4	5	15	21	6	3.39	1.08	9
		%	8%	10%	29%	41%	12%			
7	Missed understanding of the principle of Design-Build	N	2	7	13	17	12	3.59	1.12	7
		%	4%	14%	25%	33%	24%			
8	Not common of Design-Build on the market	N	3	4	13	14	15	3.69	1.18	5
		%	6%	8%	25%	27%	29%			
9	Unpredictability of expectation performance of Design-Build	N	3	7	18	20	3	3.25	0.98	10
		%	6%	14%	35%	39%	6%			
10	Owner is not much involved of project stages	N	9	14	14	8	6	2.76	1.26	13
		%	18%	27%	27%	16%	12%			
11	Lack of quality expectation	N	4	18	14	10	5	2.88	1.13	11
		%	8%	35%	27%	20%	10%			
12	Negative expectation of time performance	N	9	14	11	12	5	2.80	1.27	12
		%	18%	27%	22%	24%	10%			
13	Expected high estimated cost	N	0	5	7	21	18	4.02	0.95	2
		%	0%	10%	14%	41%	35%			
Mean								**3.48**		
Standard Deviation								**0.52**		

Table 64, Descriptive statistics for influences that affect not utilizing DB delivery method

CHAPTER 5

SUMMARY OF THE STUDY, CONCLUSION, AND RECOMMENDATIONS

This chapter presents the summary of the study, conclusion, and recommendations.

5.1 - Summary of the Study

The delivery system in the construction industries in Saudi Arabia is one of the biggest factors that affects a project's performance negatively and approximately 70% are in Saudi Arabia Public Projects.

This study compares the performance of Design-Build and Design-Bid-Build projects in terms of time and cost. The project sample number was 44 for Design-Bid-Build delivery systems and 11 for Design-Build delivery systems that are located in the eastern province of Saudi Arabia. Project types were Commercial; 8 DBB and 2 DB, Industrial; 9 DBB and 3 DB, Residential; 11 DBB and 1 DB, and Institutional; 11 DBB, projects, as well as Infrastructure projects; 5 DBB and 5 DB projects.

Contracted duration, final duration, and productivity per square meter for the design and execution stages was the information calculated to find the time growth, Contracted cost, final cost, and cost per square meter in SR comprised the information calculated to find the cost growth.

Statistics analysis used the hypothesis and equal variable t-test to find the superior performance between the D-B and D-B-B projects in terms of time and cost.

In addition, this study conducted 54 projects participants (Owner, Consultant, and Contractor) to find the factors that hinder the implementation of the D-B delivery method in execution project industries in Saudi Arabia.

5.2 – Findings

The first aim is to evaluate the performance of the DB delivery method versus the DBB in terms of time and cost.

Collecting cost and time data, then conducting an analysis for this study, was for two types of delivery method in general and for different project types: Commercial, Industrial, Residential, and Institutional projects, as well as Infrastructure projects. The following conclusions were drawn:

5.2.1- Cost Performance

Cost growth analysis in this research depends on three categories: Design and Execution Cost Growth (Total Cost Growth) and Variation Order Cost Growth Ratio and Cost in Saudi Riyal per Square Meter. It was found that:

- In general the collected information data showed that DBB were having a lower Cost Growth than the DB delivery method in Design and Implementation Cost Growth, and Variation Order Cost Growth Percentage, and Cost per Square meter. The mean of the DB is higher than the mean of the DBB delivery method for all cost performance categories: Total Cost Growth, and the Variation Order Cost Growth Ratio and the Cost in Saudi Riyal per Square Meter. However, statistically the cost performance for the DB delivery method was significantly higher than for the DBB delivery method.
- Statistically the null hypothesis for cost performance between the DB and DBB projects is accepted for Commercial, Industrial, Residential, and Infrastructure projects. Meanwhile the mean of Design and Execution Cost Growth and Variation Order Cost Growth Percentage and Cost per Unit for the DB delivery

method were higher than for the DBB delivery method for Commercial, Industrial, and Infrastructure project types except the Cost growth for design and execution in the DB commercial project were lower than for DBB commercial projects.

In addition, the cost performance for DB residential projects was lower than for DBB residential projects.

5.2.2 - Time Performance

Cost growth analysis in this research depends on three categories: Design and Execution Time Growth (Total Time Growth) and Productivity. It was found that:

- In general the productivity by Square Meter per Day for DB projects is significantly higher than for DBB projects. Total time growth for Design and Execution is almost significantly higher in DB projects than in DBB projects. The mean of total time growth and productivity for DB projects is significantly higher than for DBB projects.
- Design and Execution Time Growth of DB Commercial Projects was significantly lower than for DBB Commercial Projects and the Productivity of DBB Commercial Projects were significantly higher than for DBB Commercial Projects. Furthermore, the Time growth for design and execution in the DB delivery method was lower than the DBB delivery method for Industrial, Residential, and Infrastructure project types. In addition, the productivity of the DB delivery method was higher in Residential Projects and lower in Industrial Projects than for the DBB delivery method.

5.3 – Conclusion

The cost growth for DB projects of 11.50% was higher than the DBB projects 10.10% in regards to the design and execution stage, as well as the variation order cost growth ratio and unit cost per square meter 11.50% and 11,416 SR per square meter, respectively, for DB projects was higher than that of DBB projects 5.70% and 5,783 SR per square meter, respectively.

Time growth for DB projects 26% was lower than for DBB projects 75% in regards to the design and execution stage, as well as the productivity for DB projects 214.19 square meters per day was higher than for DBB projects 11.29 square meters per day.

Design-Build projects were superior to Design-Bid-Build in regards to the time of the design and execution stages. The Design-Bid-Build is superior to the Design-Build projects in regards to the cost for both the design and execution stages. Meanwhile, the statistical analysis in this study does not indicate a significant difference between DB and DBB projects.

5.3.1 - Factors hindering DB delivery methods

The Second part of this study is to understand the reason for not utilizing the DB delivery method in execution project industries in Saudi Arabia, due to the few samples of project data collection for the DB delivery method during the survey.

The ranking was done by mean for 13 factors and it was found that:

- The most important factors that influence the clients to not utilize the DB delivery method were described respectively as per that clarity of scope of work at an earlier time by the owner and expectation of a high estimated cost by the contractor and expected a lot of variations during the design and execution stage and the capabilities of the owner's team work.

- The lowest factors that influence the clients to not utilize the DB delivery method was described respectively as per the fact that the owner is not much involved in the project stages, negative expectation of time performance, lack of quality expectation, unpredictability of expectation performance of Design-Build.

5.4 – Recommendation

It's advised the owners of construction projects in Saudi Arabia to select DB delivery method due to the fact that in general the schedule performance of DB method better than that of DBB projects, especially for the owners of commercial projects.

In addition, it's advised the owner of residential projects to select DB rather than DBB method due to that the schedule and cost per unit performance of DB method is better than DBB method.

It's also recommended the owners to have clarity of scope of work at an earlier time with qualified team work and avoid requesting a lot of change during design and construction, prior to select DB delivery method. .

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Appendix A

Design-Bid-Build - Cost Project Data														
#	Ref.	Project Name	Location	Build up Area (m2)	Design & Supervision Cost (SAR)			Construction Cost (SAR)			Design & Construction Cost (SAR)			Project Final Price (SAR)
					Estimated	Actual	Change Order	Estimated	Actual	Change Order	Estimated	Actual	Change Order	
1	R01	**Ware House**	Dammam	135000	1,200,000	1,450,000	250,000	18,950,000	19,550,000	600,000	20,150,000	21,000,000	850,000	42,000,000
2	R02	**Resedential Building**	Dammam	180000	15,200,000	19,000,000	3,800,000	380,000,000	430,000,000	50,000,000	395,200,000	449,000,000	53,800,000	898,000,000
3	R03	**Resedential Building**	Khobar	2850	195,000	235,000	40,000	3,670,000	3,730,000	60,000	3,865,000	3,965,000	100,000	7,930,000
4	R04	**Resedential Building**	Khobar	12000	480,000	560,000	80,000	15,000,000	15,100,000	100,000	15,480,000	15,660,000	180,000	31,320,000
5	R05	**Resedintial Villa**	Khobar	1000	60,000	60,000	-	1,500,000	1,550,000	50,000	1,560,000	1,610,000	50,000	3,220,000
6	R06	**Resedintial Villa**	Khobar	1600	20,000	20,000	-	2,310,000	2,390,000	80,000	2,330,000	2,410,000	80,000	4,820,000
7	R07	**Al-Shahrani Villa**	Dammam	1250	80,000	80,000	-	1,700,000	1,813,000	113,000	1,780,000	1,893,000	113,000	3,786,000
8	R08	**Sami Al-Mutairi Villa**	Dammam	2066	122,000	122,000	-	2,900,000	3,100,000	200,000	3,022,000	3,222,000	200,000	6,444,000
9	R09	**Palm Plaza**	Khobar	36600	1,650,000	1,650,000	-	132,000,000	135,000,000	3,000,000	133,650,000	136,650,000	3,000,000	273,300,000
10	R10	**Retal Resedential Bldg**	Khobar	16800	240,000	240,000	-	34,110,538	34,863,235	752,697	34,350,538	35,103,235	752,697	70,206,470
11	R11	**BAWAN Resedential Bldg**	Khobar	10000	150,000	180,000	30,000	12,000,000	12,100,000	100,000	12,150,000	12,280,000	130,000	24,560,000
12	SC1	**Safana School**	Dammam	1875	195,000	215,000	20,000	4,720,000	4,980,000	260,000	4,915,000	5,195,000	280,000	10,390,000
13	SC2	**Zainab School**	Nuairiah	3680	409,000	459,500	50,500	7,600,000	8,198,000	598,000	8,009,000	8,657,500	648,500	17,315,000
14	SC3	**Al-Akhella Complex**	Dammam	2900	300,000	380,000	80,000	8,510,000	8,860,000	350,000	8,810,000	9,240,000	430,000	18,480,000
15	C01	**Ansab Plaza**	Khobar	4298	545,000	655,800	110,800	4,500,000	10,000,000	1,000,000	5,045,000	10,655,800	1,110,800	16,811,600
16	C02	**Park Inn Hotel**	Juabil	30200	950,000	1,300,000	350,000	25,000,000	39,000,000	14,000,000	25,950,000	40,300,000	14,350,000	80,600,000
17	C03	**Dammam Banquate**	Dammam	4500	260,000	320,000	60,000	6,200,000	7,720,000	1,520,000	6,460,000	8,040,000	1,580,000	16,080,000
18	C04	**Reinvention Office**	Juabil	8900	320,000	500,000	180,000	6,721,567	10,662,299	3,940,732	7,041,567	11,162,299	4,120,732	22,324,598
19	C05	**Rajhi Bank**	Dammam	1100	514,000	602,000	88,000	8,966,658	8,966,658	13,000	9,480,658	9,568,658	101,000	19,150,316
20	I01	**Midal Factory**	Dammam	150000	390,000	550,000	160,000	13,500,000	13,973,690	473,690	13,890,000	14,523,690	633,690	29,047,380
21	I02	**Al-Maha Factory**	Khobar	198451	150,000,000	250,000,000	100,000,000	1,490,000,000	1,785,000,000	295,000,000	1,640,000,000	2,035,000,000	395,000,000	4,070,000,000
22	I03	**Factory**	Khobar	2500	826,000	942,000	116,000	25,000,000	26,500,000	1,500,000	25,826,000	27,442,000	1,616,000	54,884,000
23	I04	**HEBA Factory**	Dammam	6400	50,000	50,000	-	8,000,000	8,000,000	-	8,050,000	8,050,000	-	16,100,000
24	I05	**Andisco Store**	Dammam	10000	70,000	90,000	20,000	13,000,000	13,320,000	320,000	13,070,000	13,410,000	340,000	26,820,000
25	I06	**Ingenia Factory**	Juabil	2500	2,000,000	3,000,000	1,000,000	20,000,000	32,500,000	12,500,000	22,000,000	35,500,000	13,500,000	71,000,000
26	I07	**ORANGE Gas Station**	Khobar	2705	99,000	134,000	35,000	4,150,000	4,744,000	594,000	4,249,000	4,878,000	629,000	9,756,000
27	I08	**SASCO Gas Station**	Ibqaiq	2445	155,000	215,000	60,000	5,992,678	6,208,100	215,422	6,147,678	6,423,100	275,422	12,846,200
28	I09	**SASCO Gas Station**	Dammam	3947	170,000	260,000	90,000	6,386,147	6,386,147	-	6,556,147	6,646,147	90,000	13,292,294
29	IS01	**Sewer and Drainage**	Nuairiah	N/A	5,600,000	8,400,000	2,800,000	56,971,543	58,680,689	1,709,146	62,571,543	67,080,689	4,509,146	134,161,379
30	IS02	**Water Tanks**	Hail	N/A	960,000	1,440,000	480,000	12,426,999	11,681,379	-745,620	13,386,999	13,121,379	-265,620	26,242,758
31	IS03	**Boundary Wall**	Nuairiah	N/A	600,000	900,000	300,000	10,830,000	11,371,500	541,500	11,430,000	12,271,500	841,500	24,543,000
32	IS04	**Water Tanks**	Hail	N/A	2,250,000	3,375,000	1,125,000	25,899,508	23,827,547	-2,071,961	28,149,508	27,202,547	-946,961	54,405,095
33	IS05	**Khobar Water Tanks**	Khobar	N/A	6,000,000	6,500,000	500,000	100,000,000	100,000,000	-	106,000,000	106,500,000	500,000	213,000,000
34	C01	**Hail Shops**	Ahsa	150000	7,000,000	9,000,000	2,000,000	750,000,000	740,500,000	-9,500,000	757,000,000	749,500,000	-7,500,000	1,499,000,000
35	C02	**Educational Office**	Nuairiah	15000	-	-	-	26,456,000	29,350,000	2,894,000	26,456,000	29,350,000	2,894,000	58,700,000
36	C03	**Educational Office**	Hail	15000	-	-	-	30,500,000	28,750,000	-1,750,000	30,500,000	28,750,000	-1,750,000	57,500,000
37	SC01	**Shaba'a School**	Shuaba'a	4500	-	-	-	9,750,000	8,760,230	-989,770	9,750,000	8,760,230	-989,770	17,520,460
38	SC02	**Schoold Building**	Jubail	10000	-	-	-	17,852,735	17,880,860	28,125	17,852,735	17,880,860	28,125	35,761,720
39	SC03	**Schoold Building**	Dammam	10000	-	-	-	18,550,000	19,346,681	796,681	18,550,000	19,346,681	796,681	38,693,362
40	SC04	**Schoold Building**	Hasa	10500	-	-	-	17,750,147	18,625,275	875,128	17,750,147	18,625,275	875,128	37,250,550
41	SC05	**Schoold Building**	Hasa	10000	-	-	-	16,952,300	17,625,850	673,550	16,952,300	17,625,850	673,550	35,251,700
42	SC06	**Schoold Building**	Hasa	10000	-	-	-	19,652,423	18,927,319	-725,104	19,652,423	18,927,319	-725,104	37,854,638
43	SC07	**Schoold Building**	Nuairiah	10000	-	-	-	18,138,250	17,753,152	-385,098	18,138,250	17,753,152	-385,098	35,506,304
44	SC08	**Schoold Building**	Nuairiah	10000	-	-	-	23,157,000	21,150,147	-2,006,853	23,157,000	21,150,147	-2,006,853	42,300,294

R= Residential, C= Commercial, IS= Infrastructure I= Industrial SC= Institutional

Design-Bid-Build - Schedule Project Data															
#		Project Name	Location	Build-up Area (m2)	Design Duration (Day)			Bids & NTP Duration	Construction Duration (Day)			Design & Construction Duration (Day)			Final Project Duration (Day)
					Estimated	Actual	Number of Change Order		Estimated	Actual	Number of Change Order	Estimated	Final Duration	Number of Change Order	
1	R01	Ware House	Dammam	135000	90	164	3	147	300	315	10	390	626	13	1016
2	R02	Resedential Building	Dammam	180000	120	180	3	210	1080	1500	10	1200	1890	13	3090
3	R03	Resedential Building	Khobar	2850	60	90	0	90	540	660	2	600	840	2	1440
4	R04	Resedential Building	Khobar	12000	180	270	0	90	720	840	1	900	1200	1	2100
5	R05	Resedintial Villa	Khobar	1000	180	360	0	45	540	720	3	720	1125	3	1845
6	R06	Resedintial Villa	Khobar	1600	30	60	2	45	540	690	4	570	795	6	1365
7	R07	Al-Shahrani Villa	Dammam	1250	60	90	0	50	480	600	2	540	740	2	1280
8	R08	Sami Al-Mutairi Villa	Dammam	2066	60	90	0	50	720	720	2	780	860	2	1640
9	R09	Palm Plaza	Khobar	36600	180	230	0	44	660	877	3	840	1151	3	1991
10	R10	Retal Resedential	Khobar	16800	60	90	0	750	720	750	1	780	1590	1	2370
11	R11	BAWAN Resedential	Khobar	10000	90	150	0	455	420	720	0	510	1325	0	1835
12	SC1	Safana School	Dammam	1875	60	110	0	90	360	540	4	420	740	4	1160
13	SC2	Zainab School	Nuairiah	3680	90	180	0	90	660	900	5	750	1170	5	1920
14	SC3	Al-Akhella Complex	Dammam	2900	120	330	0	365	300	660	3	420	1355	3	1775
15	C01	Ansab Plaza	Khobar	4298	90	195	1	180	540	740	6	630	1115	7	1745
16	C02	Park Inn Hotel	Juabil	30200	170	280	0	21	640	821	143	810	1122	143	1932
17	C03	Dammam Banquate	Dammam	4500	45	65	0	50	240	330	7	285	445	7	730
18	C04	Reinvention Office	Juabil	8900	120	140	2	34	212	456	22	332	630	24	962
19	C05	Rajhi Bank	Dammam	1100	90	160	0	397	360	480	1	450	1037	1	1487
20	I01	Midal Factory	Dammam	150000	90	120	0	50	360	600	3	450	770	3	1220
21	I02	Al-Maha Factory	Khobar	198451	730	1171	29	230	1095	2110	89	1825	3511	118	5336
22	I03	Factory	Khobar	2500	120	150	3	75	720	840	6	840	1065	9	1905
23	I04	HEBA Factory	Dammam	6400	90	90	0	360	360	360	0	450	810	0	1260
24	I05	Andisco Store	Dammam	10000	180	270	3	420	360	390	0	540	1080	3	1620
25	I06	Ingenia Factory	Juabil	2500	180	390	2	530	500	600	14	680	1520	16	2200
26	I07	ORANGE Gas Station	Khobar	2705	90	300	1	240	180	420	2	270	960	3	1230
27	I08	SASCO Gas Station	Ibqaiq	2445	90	180	0	270	210	330	3	300	780	3	1080
28	I09	SASCO Gas Station	Dammam	3947	106	173	1	316	240	420	5	346	909	6	1255
29	IS01	Sewer and Drainage	Nuairiah	N/A	90	185	1	45	840	1410	3	930	1640	4	2570
30	IS02	Water Tanks	Hail	N/A	60	145	1	45	840	1170	3	900	1360	4	2260
31	IS03	Boundary Wall	Nuairiah	N/A	90	105	1	45	720	1020	1	810	1170	2	1980
32	IS04	Water Tanks	Hail	N/A	90	156	1	45	720	1140	4	810	1341	5	2151
33	IS05	Khobar Water Tanks	Khobar	N/A	360	390	0	150	720	900	0	1080	1440	0	2520
34	C01	Hail Shops	Ahsa	150000	240	240	1	130	1080	1410	6	1320	1780	7	3100
35	C02	Educational Office	Nuairiah	15000	0	0	0	75	720	1140	4	720	1215	4	1935
36	C03	Educational Office	Hail	15000	0	0	0	75	720	1080	7	720	1155	7	1875
37	SC01	Shaba'a School	Shuaba'a	4500	0	0	0	75	450	510	1	450	585	1	1035
38	SC02	Schoold Building	Jubail	10000	0	0	0	75	720	930	1	720	1005	1	1725
39	SC03	Schoold Building	Dammam	10000	0	0	0	75	720	1260	3	720	1335	3	2055
40	SC04	Schoold Building	Hasa	10500	0	0	0	75	720	900	2	720	975	2	1695
41	SC05	Schoold Building	Hasa	10000	0	0	0	75	720	1020	2	720	1095	2	1815
42	SC06	Schoold Building	Hasa	10000	0	0	0	75	720	1140	2	720	1215	2	1935
43	SC07	Schoold Building	Nuairiah	10000	0	0	0	75	720	960	5	720	1035	5	1755
44	SC08	Schoold Building	Nuairiah	10000	0	0	0	75	720	930	5	720	1005	5	1725

R= Residential, C= Commercial, IS= Infrastructure I= Industrial SC= Institutional

Design-Build- Cost Projects Data									
#	Ref.	Project Name	Location	Build up Area (m2)	Design & Construction Cost (SAR)		Change Order		Project Final Price (SAR)
					Estimated	Actual	Number of C.O.	Additional Cost	
1	I 01	Schlumberger Plant	Dammam,	16000	315,000,000	420,000,000	176	105,000,000	420,000,000
2	I 02	Barrak Gas Station	Dhahran	5600	3,500,000	4,000,000	4	500,000	4,000,000
3	I 03	ORANGE Gas Station	Jubail	6700	2,100,000	2,400,000	6	300,000	2,400,000
4	I 04	Building accommodation	Jubail	2000000	6,600,000,000	8,000,000,000	2	1,400,000,000	8,000,000,000
5	I 05	infrastructure and buildings	Jubail	20000	1,100,000,000	1,200,000,000	1	100,000,000	1,200,000,000
6	R 01	Retal Villa (36 Villa)	Khobar	18000	24,000,000	24,000,000	0	-	24,000,000
7	C01	Oleft Hotel	Khobar	15400	230,000,000	233,000,000	1	3,000,000	233,000,000
8	C 02	Jubail Mall	Jubail	38360	50,111,000	75,575,000	4	25,464,000	75,575,000
9	IS 01	Dammam Port Download	Dammam	1,000,000	96,000,000	96,000,000	0	-	96,000,000
10	IS 02	Dammam Port Interlock	Ras Al-Khair	11200	280,000,000	290,000,000	1	10,000,000	290,000,000
11	IS 02	GAS TORBINE	Dammam	30000	140,000,000	140,000,000	0	-	140,000,000

Design-Build- Schedule Projects Data									
#	Ref.	Project Name	Location	Build up Area (m2)	Design & Construction Time (Day)		Change Order		
					Estimated	Actual	Number of C.O.	Extension Time	Project Final Price (SAR)
1	I 01	Schlumberger Plant	Dammam,	16000	1080	2040	176	480	2040
2	I 02	Barrak Gas Station	Dhahran	5600	240	420	0	180	420
3	I 03	ORANGE Gas Station	Jubail	6700	180	220	6	40	220
4	I 04	Building accommodation	Jubail	2000000	1440	2160	2	720	2160
5	I 05	infrastructure and buildings	Jubail	20000	900	900	1	0	900
6	R 01	Retal Villa (36 Villa)	Khobar	18000	360	360	0	0	360
7	C01	Oleft Hotel	Khobar	15400	540	570	1	30	570
8	C 02	Jubail Mall	Jubail	38360	540	630	4	90	630
9	IS 01	Dammam Port Download	Dammam	1,000,000	780	1140	0	0	1140
10	IS 02	Dammam Port Interlock	Ras Al-Khair	11200	780	1140	1	360	1140
11	IS 02	GAS TORBINE	Dammam	30000	240	240	0	0	240

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Design-Build Cost and Schedule Growth										
#	Ref.	Project Name	Location	Build up Area (m2)	Cost Growth				Schedule Growth	
					Design & Construction Cost Growth %	Total C.O. %	Cost / m2 (SAR/m2)		Design & Construction Time Growth %	Productivity (m2/day
1	I 01	Schlumberger Plant	Dammam,	16000	33.33%	33.33%	26,250.00		88.89%	7.84
2	I 02	Barrak Gas Station	Dhahran	5600	14.29%	14.29%	714.29		75.00%	13.33
3	I 03	ORANGE Gas Station	Jubail	6700	14.29%	14.29%	358.21		22.22%	30.45
4	I 04	Building accommodation	Jubail	2000000	21.21%	21.21%	4,000.00		50.00%	925.93
5	I 05	infrastructure and buildings	Jubail	20000	9.09%	9.09%	60,000.00		0.00%	22.22
6	R 01	Retal Villa (36 Villa)	Khobar	18000	0.00%	0.00%	1,333.33		0.00%	50.00
7	C01	Oleft Hotel	Khobar	15400	1.30%	1.30%	15,129.87		5.56%	27.02
8	C 02	Jubail Mall	Jubail	38360	50.82%	50.82%	1,970.15		16.67%	60.89
9	IS 01	Dammam Port Download	Dammam	1,000,000	0.00%	0.00%	96.00		46.15%	877.19
10	IS 02	Dammam Port Interlock	Ras Al-Khair	11200	3.57%	3.57%	25,892.86		46.15%	9.82
11	IS 02	GAS TORBINE	Dammam	30000	0.00%	0.00%	4,666.67		0.00%	125.00

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Design-Bid-Build Cost Growth							
#	Ref.	Project Name	Design & Supervision Cost Growth (%)	Construction Cost Growth (%)	Total Cost Growth (%)	Total C.O. (%)	Cost / m2 (SAR/m2)
1	R01	Ware House	20.83%	3.17%	4.22%	4.05%	311.11
2	R02	Resedential Building	25.00%	13.16%	13.61%	11.98%	4,988.89
3	R03	Resedential Building	20.51%	1.63%	2.59%	2.52%	2,782.46
4	R04	Resedential Building	16.67%	0.67%	1.16%	1.15%	2,610.00
5	R05	Resedintial Villa	0.00%	3.33%	3.21%	3.11%	3,220.00
6	R06	Resedintial Villa	0.00%	3.46%	3.43%	3.32%	3,012.50
7	R08	Al-Shahrani Villa	0.00%	6.65%	6.35%	5.97%	3,028.80
8	R09	Sami Al-Mutairi Villa	0.00%	6.90%	6.62%	6.21%	3,119.07
9	R10	Palm Plaza	0.00%	2.27%	2.24%	2.20%	7,467.21
10	R11	Retal Resedential Bldg	0.00%	2.21%	2.19%	2.14%	4,178.96
11	R12	BAWAN Resedential	20.00%	0.83%	1.07%	1.06%	2,456.00
12	SC1	Safana School	10.26%	5.51%	5.70%	5.39%	5,541.33
13	SC2	Zainab School	12.35%	7.87%	8.10%	7.49%	4,705.16
14	SC3	Al-Akhella Complex	26.67%	4.11%	4.88%	4.65%	6,372.41
15	C01	Ansab Plaza	20.33%	122.22%	111.22%	10.42%	3,911.49
16	C02	Park Inn Hotel	36.84%	56.00%	55.30%	35.61%	2,668.87
17	C03	Dammam Banquate	23.08%	24.52%	24.46%	19.65%	3,573.33
18	C04	Reinvention Office	56.25%	58.63%	58.52%	36.92%	2,508.38
19	C05	Rajhi Bank	17.12%	0.00%	0.93%	1.06%	17,409.38
20	I01	Midal Factory	41.03%	3.51%	4.56%	4.36%	193.65
21	I02	Al-Maha Factory	66.67%	19.80%	24.09%	19.41%	20,508.84
22	I03	Factory	14.04%	6.00%	6.26%	5.89%	21,953.60
23	I04	HEBA Factory	0.00%	0.00%	0.00%	0.00%	2,515.63
24	I05	Andisco Store	28.57%	2.46%	2.60%	2.54%	2,682.00
25	I06	Ingenia Factory	50.00%	62.50%	61.36%	38.03%	28,400.00
26	I07	ORANGE Gas Station	35.35%	14.31%	14.80%	12.89%	3,606.65
27	I08	SASCO Gas Station	38.71%	3.59%	4.48%	4.29%	5,254.07
28	I09	SASCO Gas Station	52.94%	0.00%	1.37%	1.35%	3,367.70
29	IS01	Sewer and Drainage	50.00%	3.00%	7.21%	6.72%	9,993.33
30	IS02	Water Tanks	50.00%	-6.00%	-1.98%	-2.02%	3,913.33
31	IS03	Boundary Wall	50.00%	5.00%	7.36%	6.86%	3,833.33
32	IS04	Water Tanks	50.00%	-8.00%	-3.36%	-3.48%	3,893.44
33	IS05	Khobar Water Tanks	8.33%	0.00%	0.47%	0.47%	3,576.17
34	C01	Hail Shops	28.57%	-1.27%	-0.99%	-1.00%	3,869.34
35	C02	Educational Office	0.00%	10.94%	10.94%	9.86%	3,547.67
36	C03	Educational Office	0.00%	-5.74%	-5.74%	-6.09%	3,525.17
37	SC01	Shaba'a School	0.00%	-10.15%	-10.15%	-11.30%	3,785.46
38	SC02	Schoold Building	0.00%	0.16%	0.16%	0.16%	3,550.63
39	SC03	Schoold Building	0.00%	4.29%	4.29%	4.12%	4,230.03
40	SC04	Schoold Building	0.00%	4.93%	4.93%	4.70%	N/A
41	SC05	Schoold Building	0.00%	3.97%	3.97%	3.82%	N/A
42	SC06	Schoold Building	0.00%	-3.69%	-3.69%	-3.83%	N/A
43	SC07	Schoold Building	0.00%	-2.12%	-2.12%	-2.17%	N/A
44	SC08	Schoold Building	0.00%	-8.67%	-8.67%	-9.49%	N/A

R= Residential, C= Commercial, IS= Infrastructure

I= Industrial SC= Institutional

Design-Bid-Build Schedule Growth						
#	Ref.	Project Name	Design Schedule Growth(%)	Construction ScheduleGrowth (%)	Total Schedule Growth (%)	Productivity (m2/day)
1	R01	Ware House	82.22%	5.00%	60.51%	132.87
2	R02	Resedential Building	50.00%	38.89%	57.50%	58.25
3	R03	Resedential Building	50.00%	22.22%	40.00%	1.98
4	R04	Resedential Building	50.00%	16.67%	33.33%	5.71
5	R05	Resedintial Villa	100.00%	33.33%	56.25%	0.54
6	R06	Resedintial Villa	100.00%	27.78%	39.47%	1.17
7	R08	Al-Shahrani Villa	50.00%	25.00%	37.04%	0.98
8	R09	Sami Al-Mutairi Villa	50.00%	0.00%	10.26%	1.26
9	R10	Palm Plaza	27.78%	32.88%	37.02%	18.38
10	R11	Retal Resedential Bldg	50.00%	4.17%	103.85%	7.09
11	R12	BAWAN Resedential	66.67%	71.43%	159.80%	5.45
12	SC1	Safana School	83.33%	50.00%	76.19%	1.62
13	SC2	Zainab School	100.00%	36.36%	56.00%	1.92
14	SC3	Al-Akhella Complex	175.00%	120.00%	222.62%	1.63
15	C01	Ansab Plaza	116.67%	37.04%	76.98%	2.46
16	C02	Park Inn Hotel	64.71%	28.28%	38.52%	15.63
17	C03	Dammam Banquate	44.44%	37.50%	56.14%	6.16
18	C04	Reinvention Office	16.67%	115.09%	89.76%	9.25
19	C05	Rajhi Bank	77.78%	33.33%	130.44%	0.74
20	I01	Midal Factory	33.33%	66.67%	71.11%	122.95
21	I02	Al-Maha Factory	60.41%	92.69%	92.38%	37.19
22	I03	Factory	25.00%	16.67%	26.79%	1.31
23	I04	HEBA Factory	0.00%	0.00%	80.00%	5.08
24	I05	Andisco Store	50.00%	8.33%	100.00%	6.17
25	I06	Ingenia Factory	116.67%	20.00%	123.53%	1.14
26	I07	ORANGE Gas Station	233.33%	133.33%	255.56%	2.20
27	I08	SASCO Gas Station	100.00%	57.14%	160.00%	2.26
28	I09	SASCO Gas Station	63.21%	75.00%	162.72%	3.15
29	IS01	Sewer and Drainage	105.56%	67.86%	76.34%	48.39
30	IS02	Water Tanks	141.67%	39.29%	51.11%	7.75
31	IS03	Boundary Wall	16.67%	41.67%	44.44%	8.00
32	IS04	Water Tanks	73.33%	58.33%	65.56%	4.35
33	IS05	Khobar Water Tanks	8.33%	25.00%	33.33%	5.80
34	C01	Hail Shops	0.00%	30.56%	34.85%	4.87
35	C02	Educational Office	0.00%	58.33%	68.75%	6.19
36	C03	Educational Office	0.00%	50.00%	60.42%	5.51
37	SC01	Shaba'a School	0.00%	13.33%	30.00%	5.17
38	SC02	Schoold Building	0.00%	29.17%	39.58%	5.70
39	SC03	Schoold Building	0.00%	75.00%	85.42%	5.80
40	SC04	Schoold Building	0.00%	25.00%	35.42%	N/A
41	SC05	Schoold Building	0.00%	41.67%	52.08%	N/A
42	SC06	Schoold Building	0.00%	58.33%	68.75%	N/A
43	SC07	Schoold Building	0.00%	33.33%	43.75%	N/A
44	SC08	Schoold Building	0.00%	29.17%	39.58%	N/A

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Appendix B

QUESTIONNAIRE SURVEY

Dear respondent,

This survey will be used as a part of Master Thesis in King Fahd University for Petroleum and Minerals (KFUPM), The collected information is for research purpose only. We would like to thank you for the time and effort in your responding in this proposal.

The aim of this questionnaire is to understand the reason of not utilizing Design-Build Delivery system for Construction Project Industries at Saudi Arabia based on the contractors and clients perspective. In order to achieve the aims, this questionnaire is divided into two parties; the first part; is general information about the respondents and the second part; is about the level of agreement or disagreement for the reason of not utilizing Design-Build Delivery method in your projects.

Please do what you can to fill this questionnaire information as fully as possible. The data collected in this questionnaire will not be showed in any way to participant's names.

Organization Profile

This section contains questions seeking information about your organization. Kindly answer the following questions either by filling the space, or, by placing a tick (√) in the appropriate box:

Organization Name: (Optional) ……………………………………………………..

What is the age of your organization in years?

- Less than 5 years
- 5 to 10 years
- 10 to 15 years
- 15 to 20 years
- 20 to 25 years
- More than 25 years

What is the number of your organization employees?

- Less than 50
- 50 to 200
- 200 to 500
- 500 to 700
- 700 to 1,000
- More than 1,000

What is the average million SR per year of construction contracts executed by your organization?

- Less than 100 Millions
- 100 to 200 Millions
- 200 to 500 Millions
- 500 to 700 Millions
- 700 to 1,000 Millions
- More than 1,000 Millions

Where is the location of your organization head office?

- Dammam
- Khobar
- Dhahran
- Jubail
- Other, please specify……………………………………………………………

Respondent Profile

This section contains questions seeking information about the respondent of this questionnaire. Kindly answer the following questions either by filling the space, or, by placing a tick (√) in the appropriate box

Respondent's Name:………………………………………………………………..

Respondent's E-mail address:…………………………………………………………..

Respondent's job title in the organization:………………………………………….

What is your educational level?

- Diploma
- Bachelor Degree
- Master Degree
- Doctorate of Philosophy

How many years you have been in your current position?

- Less than 5 years
- 5 to 10 years
- 10 to 15 years
- 15 to 20 years
- 20 to 25 years
- More than 25 years

How any years you have experience in construction industry field?

- Less than 5 years
- 5 to 10 years
- 10 to 15 years
- 15 to 20 years
- 20 to 25 years
- More than 25 years

How many years you have been in your current organization?

- Less than 5 years
- 5 to 10 years
- 10 to 15 years
- 15 to 20 years
- 20 to 25 years
- More than 25 years

Instructions: Check (√) one of the boxes in each item below according to the reason of not utilizing Design-Build in your project.					
What's the level of agreement or disagreement to evaluate the reason of not utilizing DB delivery method in your projects?	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
Capabilities of owner team work.					
Clarity of scope of work is not determined at earlier time by owner					
Expectation of many changes during design and construction					
Capabilities of contractors at market.					
No professional practice by contractors					
Follow Government procurement system					
Miss-understanding of the principle of Design-Build					
Not common of Design-Build on the market					
Unpredictability of expectation performance of Design-Build					
Owner is not much involved of project stages					
Lack of quality expectation					
Negative expectation of time performance by owners					
Expected high Estimated cost from contractor					

VITAE

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